THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. I.

No. X.—OCTOBER, 1894.

ORIGINAL ARTICLES.

I.—On a Collection of Jurassic Cephalopoda from Western Australia—Obtained by Harry Page Woodward, F.G.S., Government Geologist—with Descriptions of the Species.

By G. C. Crick, A.R.S.M., F.G.S.,
of the British Museum (Natural History).

(PLATE XIII.)

(*Continued from the September Number*, p. 393.)

Ammonites (Sphæroceras, Bayle).

Ammonites (*Sphæroceras* ?) *Woodwardi*,[1] sp. nov. (Pl. XII. Figs. 6*a* and *b*.)

Sp. char.—Shell (cast) discoidal, somewhat inflated, rather rapidly increasing. Whorls somewhat inflated, very convex on the periphery, less convex on the sides, rounded near the umbilicus. Umbilicus moderately wide, occupying nearly one-third of the diameter of the shell. Number of whorls and amount of inclusion unknown. Height of outer whorl rather more than one-third of the diameter of the shell. Each whorl ornamented with about 20 short, thick, umbilical ribs, each of which commences at the suture, extends radially or with a very slight forward inclination over one-fourth of the width of the lateral area, and terminates in a radially-elongated tubercle. Each tubercle gives rise to three, or more rarely to two, subangular ribs (in the cast), which pass uninterruptedly over the periphery. There are about 48 of these ribs to a whorl; at the periphery, the interspaces are twice the width of the ribs. Length of body-chamber unknown. Margin of the aperture prominent, provided on each side with an apophysis. Septa and suture-line unknown. Test not preserved.

Dimensions:—

Diameter of the shell	60 mm.
Width of umbilicus	20 ,,
Height of last whorl	22 ,,
Thickness of last whorl	16+ ,,

* Since the fossil has been somewhat distorted, these dimensions must be considered only as approximate; the height of the outer whorl has probably been somewhat increased, whilst the thickness of the whorl has been considerably reduced.

Remarks.—The only example representing this species is a rather crushed natural cast of the greater portion of the outer whorl, much abraded on one side. The inner whorls are not visible, and unfortunately there is no trace of the suture-line. A portion of the mouth-border is preserved, and there are remains of the prominent base of one of the lateral apophyses.

[1] Not *Ammonites Woodwardi*, H. G. Seeley, Ann. Mag. Nat. Hist. [3], vol. xvi. 1865, p. 236, pl. xi. f. 3, which probably belongs to the section *Hoplites*, Neumayr.

Affinities and differences.—In its general form and ornamentation this species closely resembles *Ammonites Sauzei*, d'Orbigny (Pal. Franç. Terr. Jur. vol. i. 1842, p. 407, pl. cxxxix.). A specimen of the latter from the Inferior Oolite of Sherborne, Dorset (Brit. Mus. No. C. 3230), 61 mm. in diameter, gives the following measurements: Width of umbilicus, 19 mm.; height of outer whorl, 24 mm.; thickness of outer whorl, 30 mm. Allowing for the compression of the Australian specimen, d'Orbigny's species was probably a more inflated shell with somewhat coarser ornaments and fewer umbilical ribs (14–15).

In its sculpture *Ammonites Bainii*,[1] Sharpe, from Sunday River, S. Africa, somewhat resembles the present species, but it has much more inflated whorls, and a narrower and deeper umbilicus.

From such forms as *Ammonites biplex*,[2] J. Sowerby, the present species is at once distinguished by the presence of a tubercle at the point of bifurcation of each umbilical rib.

In proposing for the Australian form the specific name *Woodwardi*, the writer has great pleasure in associating with the fossil the name of Mr. H. P. Woodward, Government Geologist, Western Australia.

Locality.—Champion Bay, Western Australia.

Ammonites (*Sphæroceras*) *semiornatus*, sp. nov. (Pl. XIII. Figs. 1*a*, *b*.)

1870. *Ammonites Brocchii*, C. Moore, Quart. Journ. Geol. Soc. vol. xxvi. pl. xv. f. 4.

Sp. char.—Shell discoidal, somewhat inflated; greatest thickness at a point distant from the umbilicus about one-third of the width of the lateral area, about one-third of the diameter; height of outer whorl about one-third of the diameter of the shell. Whorls six; inclusion two-thirds, diminishing considerably in the outer whorl, so that at the commencement of the outer whorl the inclusion is not one-half; umbilicus wide, rather deep, exposing the inner area of the whorls. Suture-line imperfectly seen, and depth of chambers unknown. Whorl lunate in section at base of body-chamber, and about as wide as high, becoming at the anterior part of the body-chamber more elliptical in section, and rather higher than wide; periphery convex, forming a continuous curve with the sides; inner area sloping towards the umbilicus, feebly convex. Each whorl ornamented with about twenty-two primary ribs, slightly curved and forwardly inclined, extending from the suture over about one-third of the width of the lateral area; each then dividing into three, or more rarely into two, less prominent ribs which cross the periphery without interruption, the number of these peripheral ribs being about sixty-nine to a whorl. Up to the point where the diameter of the umbilicus is 8 mm. the inner area of the whorls (as seen within the umbilicus) is quite smooth.

Dimensions:—

Diameter of shell	61	mm.
Width of umbilicus	22·5	,,
Height of outer whorl	20	,,
Thickness of outer whorl	17·5	,,

The specimen from which the above measurements were taken has a maximum diameter of 64 mm., but at this diameter the other dimensions cannot be so accurately determined. The anterior portion of the body-chamber appears to be slightly crushed, so that the thickness of the outer whorl as given above is probably too small.

Remarks.—The description given above is based upon a single

[1] Trans. Geol. Soc. [2], vol. vii. 1847, p. 197, pl. xxiii. f. 2. Pavlow (Bull. Soc. Imp. Nat. Moscow, N.S. vol. v. 1892, p. 493) places this species in a division (*Astieria*) of Neumayr's genus *Oleostephanus*.

[2] Min. Con. vol. iii. p. 168, pl. ccxciii. 1821.

specimen 64 mm. in diameter. It is a natural cast, and bears only fragments of the test; its outer whorl appears to have been occupied by the body-chamber, traces of the septa being seen at the commencement of this whorl.

Having examined the specimen figured by Moore as *Ammonites Brocchii*,[1] I believe it is to be referred to the present species. Its dimensions are as follows:—

Diameter of shell	92 mm.
Width of umbilicus	33 ,,
Height of outer whorl	about 33 ,,

The thickness of the outer whorl at a diameter of 72 mm. is 36 mm.; beyond this point the specimen is much crushed. The shell is somewhat distorted, so that the width of the umbilicus is probably exaggerated. Its suture-line cannot be made out, but around the umbilicus can be seen the compressed, forwardly-inclined, short primary ribs, each giving rise to three or four prominent ribs, which pass without interruption over the peripheral area.

To the present species may also probably be referred a specimen (No. C. 4709) in the British Museum (Nat. Hist.), from "the Greenough, Champion Bay, Australia." It is part of a specimen 127 mm. in diameter; the inner whorls up to a diameter of 25 mm. are fairly well preserved, the innermost being perfectly smooth; about half of the outer whorl is present and in fair condition, and shows the compressed umbilical tubercles or short prominent primary ribs, each branching into three less prominent, but well-marked, ribs, which cross the periphery without interruption. On the anterior half of the outer whorl the primary ribs are more forwardly-inclined than on the posterior half. A projection on the lateral area at the anterior extremity of the specimen may be a portion of the prominent mouth-border. The sculpture of the posterior part of the outer whorl greatly resembles that of the large specimen from Cape Riche, which I have referred to *Ammonites* (*Perisphinctes*) *Championensis* (see p. 436), but the latter appears to have been a more inflated shell.

Affinities and differences.—J. Sowerby's type-specimens of *Ammonites Brocchii*[2] are much more inflated than the present species, whilst the type-specimen of *Ammonites Brodiæi*[3] of the same author has more distinct and somewhat larger primary ribs and very prominent tubercles at the points of subdivision of the primary ribs. *Ammonites contractus*[4] of J. de C. Sowerby is a much more inflated shell with a smaller umbilicus. D'Orbigny's figure of *Ammonites linguiferus*[5] represents a more inflated shell, with more numerous ribs and more prominent lateral tubercles; and *Ammonites dimorphus*[6] of the same author has fewer whorls, a differently-formed umbilicus, and its whorls bear constrictions at nearly regular intervals.

[1] Quart. Journ. Geol. Soc. vol. xxvi. (1870), pl. xv. f. 4.
[2] Min. Con. vol. ii. p. 233, pl. 202, both figs. [Brit. Mus. No. 43906].
[3] Min. Con. vol. iv. p. 71, pl. 351 [Brit. Mus. No. 43905].
[4] Min. Con. vol. v. p. 162, pl. 500, f. 2.
[5] Pal. Franç. Terr. Jur. vol. i. pl. 136.
[6] Pal. Franç. Terr. Jur. vol. i. pl. 141.

Compared with *Ammonites Gervillii*, J. Sowerby,[1] [*Ammonites Brongniartii* (*pars*), A. d'Orbigny,[2]] the Australian fossil is less inflated and differently ornamented, whilst the greater inclusion of its whorls, its narrower umbilicus, and the smoothness of its inner whorls distinguish it from *Ammonites polymerus*, W. Waagen[3] [*Ammonites Brongniartii* (*pars*) d'Orbigny].[4]

The British Museum Collection contains examples of an apparently undescribed species from the Inferior Oolite of Dundry, Somerset, which resemble the present species most closely; they have, however, a somewhat larger umbilicus, finer ornaments, and their inner whorls (as seen within, the umbilicus) are distinctly ribbed, even where the umbilicus has a diameter of only 2·5 mm.

Locality.—Champion Bay, Western Australia.

Ammonites (Perisphinctes, W. Waagen).

Ammonites (*Perisphinctes*) *Championensis*, sp. nov. (Pl. XIII. Figs. 2 *a*, *b*, and *c*.)

Sp. char.—Shell (cast) discoidal, with somewhat inflated whorls; greatest thickness near the margin of the umbilicus, exact thickness unknown; outer whorl about two-fifths of the diameter of the shell in height. Number of whorls not seen; inclusion (in the outer whorl) about three-fifths; umbilicus not very deep, wide, about one-third of the diameter of the shell in width. Whorl somewhat oval or almost lunate in section, probably wider than high; indented to about two-fifths of its height by the preceding whorl; periphery probably narrowly convex; sides convex; inner area steep, almost perpendicular, slightly convex. Chambers shallow. Suture-line rather complex, incompletely known; outer saddle only partly known; the first lateral lobe deep, narrow, trifid; the first lateral saddle much broader than the first lateral lobe, divided into four principal branches, that forming the most anterior portion of the suture-line being again divided by a secondary lobe into two branches, the outer of which is again subdivided by a small lobe; the second lateral lobe scarcely one-half the size of the first lateral lobe, indistinctly trifid, the median portion being very short; the second lateral saddle small, divided by a small lobe into two unequal branches, the inner of which is again subdivided by a minute lobe; between the second lateral saddle and the suture of the shell three auxiliary lobes and saddles. Each whorl ornamented with about nineteen or twenty compressed, not very elevated, short ribs, or radially elongated tubercles, each giving rise to three or four rounded, slightly elevated ribs, thirty-eight of which can be counted in half a whorl, the interspaces being of about the same width as the ribs.

Dimensions:—

Diameter of the shell	about	115 mm.
Width of umbilicus		39 ,,
Height of outer whorl	about	45 ,,
Thickness of outer whorl		(?) ,,

The thickness of the outer whorl cannot be ascertained, since only one side of the specimen is preserved.

Remarks.—The above diagnosis has been drawn up chiefly from a natural cast about 115 mm. in diameter, consisting of one side of the outer whorl fairly well preserved, bearing fragments of the test and exhibiting the greater part of the suture-line; the inner whorls are not preserved. The collection, however, includes another speci-

[1] Min. Con. vol. ii. p. 189, pl. clxxxiv. A, fig. 3.
[2] Pal. Franç. Terr. Jur. i. p. 403, pl. 137, ff. 3, 4 (*non* ff. 1, 2, 5).
[3] Ueber die Zone des *Ammonites Sowerbyi*, Benecke's Geogn.-paläont. Beiträge, vol. i. p. 605.
[4] Pal. Franç. Terr. Jur. i. p. 403, pl. 137, ff. 1, 2 (*non* ff. 3, 4).

men, probably referable to this species, which exhibits a portion of the suture-line that supplements in a certain degree the suture-line of the example selected as the type. The collection also contains, from "Cape Riche, about 50 miles E. of Albany," a large specimen 160 mm. in diameter, which is probably a more mature example of this species. It consists of the outer whorl only. Although its suture-line cannot be made out, its general form resembles that of the present species so closely that it is referred to this species.

The present species appears to be represented in the British Museum Collection by a crushed and distorted portion of the outer whorl of an example from "the Greenough, Champion Bay," about 110 mm. in diameter (No. C. 4708). It bears fragments of the test.

Probably to this species may also be referred an example in the collection of Western Australian fossils in the Bath Museum. It is labelled "*Ammonites macrocephalus*"; but is not the specimen figured by Moore. It has the following dimensions: Diameter of shell, 109 mm.; width of umbilicus, 37 mm.; height of outer whorl above preceding whorl, 27 mm.; thickness of outer whorl, 40 mm.; width (as seen within the umbilicus) of the penultimate whorl at the greatest diameter of the shell, 12 mm. The body-chamber commences where the shell has a diameter of 88 mm., and therefore occupies nearly a whorl.

Affinities and differences.—This species greatly resembles *Ammonites Cautleyi*,[1] Oppel, from the Jurassic rocks of Laptel, in Gnari-Khorsum, Thibet; but Oppel's species possesses constrictions and is a more compressed shell. Unfortunately the suture-line is not available in Oppel's species for comparison. Compared with *Ammonites albineus*,[2] Oppel, from the Oxfordian of Würtemberg, the Australian species is more robust and has a different suture-line. In Oppel's species, moreover, the ribs which cross the periphery disappear at a diameter of 75 mm., but they are quite distinct in the Australian specimen at a diameter of 110 mm. The present species differs from *Ammonites polymorphus*,[3] d'Orbigny, from the Inferior Oolite, in having more inflated whorls, larger and fewer tubercles around the umbilicus, and ribs which are uninterrupted on the peripheral area. Although somewhat resembling *Perisphinctes obtusicosta*[4] and *Perisph. paramorphus*,[5] Waagen, from the Callovian of Cutch, the Australian species has much finer ornaments and a very different suture-line.

The general arrangement of the suture-line is not unlike that of *Olcostephanus Brancoi*,[6] Neumayr and Uhlig, but the lattter is a more inflated and more coarsely ornamented species. The ornamentation of the present form agrees somewhat closely with that of *Olcostephanus Keyserlingi*,[7] Neumayr and Uhlig, but the suture-line of

[1] Pal. Mittheil. p. 279, pl. lxxviii. figs. 1*a*, *b*; 2*a*, *b*.
[2] *Ibid.* p. 161, pl. l. figs. 3*a*, *b*.
[3] Pal. Franç. Terr. Jur. vol. i. 1842, p. 379, pl. cxxiv.
[4] Pal. Indica, Jurassic Fauna of Cutch, vol. i. (Cephalopoda), p. 146, pl. xxxviii. figs. 1*a*, *b*; 2; 3*a*, *b*.
[5] *Ibid.* p. 162, pl. xlvi. figs. 1*a*, *b*; 2*a*, *b*; pl. xlvii. fig. 3.
[6] Palæontographica, vol. xxvii. p. 156, pl. xxvi. fig. 1.
[7] *Ibid.* p. 155, pl. xxvii. figs. 1–3.

the latter differs considerably from that of the Australian species. *Ammonites polyptychus*,[1] Keyserling, resembles the Australian species in its external form, but is distinguished by its dichotomous ribs and the form of its suture-line. *Ammonites arbustigerus*,[2] d'Orbigny, occurring in the Bathonian of France, is a closely allied species; but the Australian form is distinguished by the greater prominence of its short umbilical ribs, by its finer sculpture, and by its suture-line. The sculpture of the shell and the form of the suture-line distinguish the present species from the form figured by d'Orbigny as *Ammonites planula*[3] from the Bathonian of France.

Localities.—Champion Bay; Cape Riche, E. of Albany, Western Australia.

Ammonites (*Perisphinctes*) *robiginosus*, sp. nov. (Pl. XIII. Figs. 3 *a* and *b*.)

Although a complete diagnosis of the species cannot be given the following characters may be noted :—

Shell (cast) discoidal, rather widely umbilicated; its greatest thickness at a short distance from the inner edge of the whorl, about two-sevenths of the diameter of the shell; height of outer whorl about equal to its thickness. Umbilicus wide, probably about three-sevenths of the diameter of the shell in width. Whorl obtusely cordate in section, about as wide as high; indented to about one-fourth of its height by the preceding whorl; periphery rather broadly convex; sides somewhat flattened, sloping away from the periphery; inner area sloping towards the umbilicus. The cast is ornamented with a number of primary umbilical ribs, or very compressed, elongated tubercles, having a decided forward inclination; each primary rib divides into three secondary rounded ribs, which cross the periphery without interruption, and are separated by interspaces of rather more than their own width.

Remarks.—This species is represented by a portion of the outer whorl of an example of about 160 or 170 mm. in diameter. It is a natural cast in a ferruginous matrix; one side is fairly well preserved; the other is crushed and much weathered. It exhibits no trace of the suture-line. Its extreme length measured along the median line of the periphery is about 200 mm., the radius of curvature of the periphery being about 86 mm. In a length of 173 mm. along the periphery there are 21 peripherial ribs, which are connected with 7 primary ribs. The latter are about 12 mm. apart, whilst the secondary ribs have a thickness of about 3 mm., the interspaces being a little wider than the ribs.

Affinities and differences.—The present species is very nearly related to *Ammonites Wagneri*, Oppel,[4] from the Bathonian of France, but the primary ribs of the Australian fossil are straighter, more prominent, and trifurcate more regularly. Compared with d'Orbigny's figures[5] of *Ammonites Panderi*, Eichwald, the present

[1] Petschora-Land, 1846, p. 327, pl. xxi. figs. 1–3; pl. xxii. fig. 9.

[2] Pal. Franç. Terr. Jur. vol. i. 1842, p. 414, pl. cxliii.

[3] Pal. Franç. Terr. Jur. vol. i. 1842, p. 416, pl. cxliv. According to Oppel (Juraformation, p. 477), d'Orbigny's figure does not represent Hehl's *Amm. planula*; he, therefore, alters the name of d'Orbigny's species to *Wagneri*.

[4] A. Oppel, Die Juraformation, 1856–58, p. 477 [*Ammonites planula*, d'Orbigny, Pal. Franç. Terr. Jur. vol. i. p. 416, pl. cxliv. (*non* Hehl)].

[5] D'Orbigny, in Murchison, de Verneuil and de Keyserling, Géologie de la Russie d'Europe et des montagnes de l'Oural, vol. ii. 1845, p. 430, pl. xxxiii. figs. 1–5 (figs. 1, 2 especially).

species has the primary ribs proportionately nearer together, and the secondary ribs proportionately finer. Its primary and secondary ribs are straighter than in *Ammonites uralensis*, d'Orbigny,[1] and cross the periphery without interruption.

Locality.—Champion Bay, Western Australia.

Of the fossils referred to in the foregoing descriptions the *Belemnites*, *Nautilus*, and *Ammonites* (*Dorsetensia*) are preserved in a yellowish limestone, the *Ammonites* (*Stephanoceras*) sp. and *Ammonites* (*Perisphinctes*) *robiginosus* in a highly ferruginous matrix, and the rest in a red or red and yellow limestone, but the specimens are not accompanied by any notes on the sequence of the beds from which they were obtained. The Mesozoic rocks, however, in the portion of Western Australia whence the fossils were derived, have been described by Mr. H. Y. L. Brown in his "Report on a Geological Exploration of that portion of the Colony of Western Australia lying southward of the Murchison River and westward of Esperance Bay." Referring to the rocks of the "Mesozoic or Secondary Epoch—Oolitic Period," Mr. Brown says: "The character of the strata belonging to this period may be described as follows: Beds of highly ferruginous clay, stone, or shale, sandstones, grits, conglomerates, clays, and limestone, placed in horizontal layers upon the older rocks, which originally they must have almost entirely covered, but have since been cut into and denuded to a great extent from off them, in such manner as to leave tablelands, isolated table hills, and peaks with steep escarpments and slopes. Their average elevation is about 600 feet above sea-level. The surface of this formation is generally coated with a deposit of sand, arising from the weathering of the sandstones, the larger areas being known by the name of sand plains. There are two principal areas occupied by this formation. The first, which varies in width from 10 to 30 miles, extends from the neighbourhood of Gingin and Yatheroo to the Murchison, and probably a long distance farther northward, in a line more or less parallel to the coast. Proceeding eastward it thins out, and only exists there as outliers and cappings on the hills. Its average thickness, where best developed, is some 400 feet. The second area commences near Cape Riche, and stretches in a north-east direction beyond the Phillips River, thinning out eastward to mere cappings on the hills.

"The uppermost beds in the first-named area are generally more ferruginous than the lower, and consist of highly ferruginous concretionary claystone, shale, and grit.

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"The great denudation which has operated since the close of this period has removed a great portion of the rocks, leaving the remainder as undulating plateaux and flat-topped hills, at the bases of which the older rocks outcrop. As a rule these strata are horizontal, although in some cases a slight undulating dip is perceptible. The interstratified beds of white, yellow, and sometimes ferruginous

[1] D'Orbigny, *ibid.* p. 429, pl. xxxii. figs. 6–10.

limestone, attaining the thickness of 30 feet, which occur chiefly in the neighbourhood of Champion Bay, do not seem to be persistent, but are found as it were in patches, which gradually thin out. As the limestone composing them is made up of shells, which in some cases have consolidated into a solid rock, in others have retained their original form, it seems most probable that the accumulation of shells in hollows, in the ancient sea-beds, is the cause of their now being found in isolated areas. The most common fossils found includes species belonging to the [families] *Ammonitidæ, Belemnitidæ, Ostreidæ, Pectinidæ, Trigonidæ, Rhynchonellidæ,* etc. These fossils are generally found in the limestone, whole masses of rock being composed of them; they are also found in the hard ferruginous shale and sandstone, in which case they have been converted into oxide of iron. In a paper published in the Proceedings of the Geological Society, the author, Mr. C. Moore, considers the fossils from these beds to represent the fossil fauna of the Lias and Lower Oolitic formations of England.

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"The second principal area of this formation, which embraces the country extending from near Cape Riche to beyond the Phillips River, consists of a series of horizontal sandstones, grits, and conglomerates, capped generally by the usual ferruginous claystones, the whole thinning out on to the granite along its northern boundary at a level of from 600 to 700 feet above the sea, and forming level plains and table hills, with steep escarpments, along the Gairdner, Fitzgerald, Hamersley, Phillips, and Jerdicart Rivers. To the southward and eastward the formation, which attains a thickness of some three or four hundred feet, rests on the slaty rocks of the Mount Barren and Jerdicart country. In lithological and stratigraphical character and position, they are almost precisely similar to the same formation in the more northern parts of the colony. White marly saliferous sandstones, ferruginous grits and claystones, conglomerate, reddish sandstones, etc., are the principal rocks met with. Perfect specimens of fossil sponges are frequent in some of the caves which occur along the escarpments, hanging from the roof and sides, where the rock has weathered away; worn casts are also abundant. Mainbenup, near Esperance Bay, is the farthest point eastward where I have observed the formation. At Cape Riche beds of white and mottled sandstone, overlying granite, form low but steep cliffs along the shore of the bay."

The present collection of Cephalopoda confirms the view expressed by Clarke[1] and by Moore[2] as to the existence of rocks of Lower Oolite age in Western Australia. Possibly the highly ferruginous rocks may represent a somewhat higher portion of the Oolite, but the evidence of the present collection is by no means conclusive. No species of Middle Liassic age has been recognised in the collection.

[1] Quart. Journ. Geol. Soc. vol. xxiii. (1867), p. 9.
[2] *Ibid.* vol. xxvi. (1870), p. 230.

The species here described do not appear to be in any way related to the forms which have been recorded [1] from New Guinea.

It may be observed in conclusion that an excellent Geological Sketch-map of Western Australia by the Government Geologist, Mr. Harry Page Woodward, F.G.S., has recently been issued.

EXPLANATION OF PLATES XII. AND XIII.

[All the figures are drawn one-half the natural size unless otherwise stated.]

PLATE XII.

Fig. 1. *Nautilus perornatus*, sp. nov.: *a*, lateral view, showing portions of the test, and the course of the suture-lines; *b*, peripheral view; *c*, portion of the test on the periphery. *a* and *b* are drawn one-fourth nat. size, *c* is drawn nat. size.

Fig. 2. *Ammonites* (*Dorsetensia*) *Clarkei*, sp. nov.: *a*, lateral view; *b*, front view; *c*, suture-line.

Fig. 3. Suture-line traced from the specimen figured by Moore (Quart. Journ. Geol. Soc. vol. xxvi. (1870), pl. xv. fig. 2) under the name of *Ammonites radians*; nat. size.

Fig. 4. *Ammonites* (*Stephanoceras*) *Australis*, sp. nov.: *a*, lateral view; *b*, peripheral view.

Fig. 5. *Ammonites* (*Stephanoceras*), sp.: *a*, lateral view; *b*, peripheral view.

Fig. 6. *Ammonites* (*Sphæroceras?*) *Woodwardi*, sp. nov.: *a*, lateral view; *b*, peripheral view.

PLATE XIII.

Fig. 1. *Ammonites* (*Sphæroceras*) *semiornatus*, sp. nov.: *a*, lateral view; *b*, peripheral view.

Fig. 2. *Ammonites* (*Perisphinctes*) *Championensis*, sp. nov.: *a*, lateral view; *b*, front view; *c*, portion of the suture-line. The right-hand portion of the first lateral lobe may not be quite correct, the fossil being badly-preserved at this part.

Fig. 3. *Ammonites* (*Perisphinctes*) *robiginosus*, sp. nov.: *a*, lateral view of fragment devoid of septa; *b*, section of whorl at S.

All the specimens are from near Champion Bay, Western Australia.

II.—On some Life Zones in the Lower Palæozoic Rocks of the British Areas, as defined mainly by Researches during the Past 30 Years.

By Henry Hicks, M.D., F.R.S., F.G.S.

(*Continued from the September Number, page* 405.)

Middle Cambrian.

From the foregoing remarks it will be seen that the Middle Cambrian, as at present defined, is characterized by having numerous Life Zones in which, usually, species of the genus *Paradoxides*, or of some closely allied forms, may be considered the dominant organisms. Up to the present the genus *Olenellus*, so typical of the Lower Cambrian rocks, has not been found in direct association with *Paradoxides*, but some of the associated genera are equally characteristic both of the Lower and of the Middle Cambrian.[2] The *Olenellus* fauna, as a whole, seems to have dis-

[1] R. Etheridge, *fil.*, Records Geol. Surv. New South Wales, vol. i. pt. 3, 1889 (1890), pp. 172–179, pl. xxix.

[2] Mr. G. F. Matthew, who has worked out the zones in the Cambrian rocks of New Brunswick, Canada, with much care and success, has recently described a new

appeared from the areas as depression went on, and though, as I have already stated, there are some signs of a slight physical change at the close of the Lower Cambrian, I believe that the main cause why there should be no greater admixture of organisms, which evidently were suitable to live under like conditions, was that the fauna which first appeared, and which, to a certain extent, would cling to the shores and occupy shallow basins, would pass on to fresh areas as the depression increased.[1] The tendency to migrate along certain lines, and to follow like conditions, would undoubtedly have a powerful influence with the organisms even at this early period in the world's history, and many of the apparent difficulties which crop up when an attempt is made to trace the order of development will be brushed aside as Palæontology and Biology join hand in hand more closely in these investigations. To my mind no portion of the geological record can be more intensely interesting to biologists than that which contains the history of these earliest known organisms, as we have to deal only with marine faunas with a comparatively limited number of types which, of necessity, would be far less liable to be affected by disturbing influences than land faunas. When working out the Life History in the Cambrian rocks at St. David's, I kept constantly in mind the possibility of adding evidence in favour of the theory of evolution, and as this could only be hoped for by the adoption of a minute subdivision of the main Life Zones, I gave a section in my first paper, published in the Proceedings of the Liverpool Geological Society in 1863, showing five sub-zones in a thickness of 214 feet, with names of all the genera and species found in each. At this time the upper portion only of the Menevian (then called Lower Lingula Flags) had yielded any fossils. Lower zones were afterwards found and worked out on the same principle, and in the year 1872 I was able to state that[2] "the additions made to the fauna of the Cambrian rocks by these researches include no less than fifty-two new species, belonging to twenty-three genera. The following table shows to what orders these belong, and in what proportion they occur in these early rocks :—

Trilobites	10	genera	including	31	species
Bivalve Crustaceans	4	,,	,,	4	,,
Brachiopods	4	,,	,,	6	,,
Pteropods	3	,,	,,	6	,,
Sponges	1	genus	,,	4	,,
Cystideans	1	,,	,,	1	,,

genus, *Protolenus*, which, he says, is there the characteristic fossil of the *Olenellus* zone ("Pre-*Paradoxides* beds"). With it is associated the genus *Ellipsocephalus*, which occurs in Europe in the *Paradoxides* beds, as well as in those containing *Olenellus* (see Canadian Record of Science, October, 1892).

[1] Mr. C. D. Walcott, in his most instructive monograph "The Fauna of the Lower Cambrian or *Olenellus* Zone," says, at p. 594, "The cause of the abrupt change from the *Olenellus* to the *Paradoxides* fauna is not yet fully recognised. While a considerable portion of the genera pass up, very few of the species are known to do so, and in none of the sections has there been found a commingling of the characteristic species of the Lower and Middle Cambrian."

[2] Quart. Journ. Geol. Soc. vol. xxviii. p. 173.

If we now add to these the Annelids which had been previously discovered in these rocks, we have at least seven orders represented in this fauna, the earliest at present known. These same groups are also more or less present and tend to characterize these early deposits wherever found; but no country has, up to the present time, produced a more varied fauna or a greater richness in types than England. Scandinavia has a larger number of species, but not so many groups." I then give a table showing the number of "forms discovered in the Lowest or *Paradoxides* Zone in different parts of the world," from which "it will be observed that England has produced eight of these groups, whilst none of the other countries has yielded more than five. It is, however, most interesting to note the similarity of types in regions so far apart, and the close resemblance of the faunas." The researches which have been carried on in the Cambrian rocks since that time, though they have added greatly to the number of forms, especially in America, owing to the labours of Mr. Ford, Mr. G. F. Matthew, Mr. C. D. Walcott, and others, have mainly strengthened the evidence in regard to the similarity of types. The still earlier faunas since made out in Scandinavia, Russia, and America also show that the following conclusions given in my paper were, in the main, fully warranted: "The fact also that Trilobites had attained their maximum size at this period, and that forms were present representative of almost every stage of development, from the little *Agnostus* with two rings to the thorax, and *Microdiscus* with four, to *Erinnys* with twenty-four, and blind genera along with those having the largest eyes, leads to the conclusion that, for these several stages to have taken place, numerous previous faunas must have had an existence, and, moreover, that even at this time, in the history of our globe, an enormous period had already elapsed since life first dawned upon it." In so minute a subdivision as I at first adopted it was scarcely to be expected that the zones would be of equal value; but the plan nevertheless often furnished information of much interest. For instance, in one section at what appeared to be a new horizon a form of *Paradoxides* was found which seemed to differ materially from the *Paradoxides* (*P. Hicksii*) in the next zone, and I was only able to satisfy myself that it was a young specimen of that species by finding others showing intermediate stages in association with fully grown specimens. Five main zones characterized by new species of *Paradoxides* were made out, and in each of these new species of the more important associated forms also occurred. Though five species of *Paradoxides* only were made out at St. David's, three species of the very closely allied genera *Plutonia* and *Anopolenus* were also discovered. *Plutonia*, characterized mainly by its spinous ornamentation and wide ribs, a Trilobite of gigantic size, equalling, if not exceeding, the largest *Paradoxides*, must have been a formidable-looking Crustacean in these early seas. Hitherto, it has only been found at the base of the Middle Cambrian at St. David's, and one species only has been discovered. The largest *Paradoxides* (*P. Davidis*), on the other hand, occurs in the highest

beds. In my paper in the Quart. Journ. Geol. Soc. in 1872, after giving a minute description of the strata from the base of the Cambrian to the Lingula Flags and the evidences of the physical conditions under which they had been deposited, I added the following remarks: "These successive changes, producing such varied conditions of deposit, must have had much to do with causing barrenness in parts of the strata, and with the appearance, on the other hand, of successive zones of animal life. The continuation of the same genera through a great thickness of shore or shallow-water deposits, as is the case in the Longmynd (now called Caerfai and Solva Groups) and Lingula Flags and the rapid dying out and shorter range of the genera in finer beds or deep sea-deposits, like the bulk of the Menevian Group, are interesting facts, and deserving of consideration when we seek for natural laws to account for the conditions presented to us at these early periods." Though a considerable number of the St. David's species have been found in North Wales in beds almost identical in character with those at St. David's, two species only of *Paradoxides*, viz. *P. Hicksii* and *P. Davidis*, have as yet been determined. They hold there exactly the same position in relation to one another as they do at St. David's, and I have no doubt a careful examination of the underlying beds will show that the Lower Zones occur there also. Soon after we had discovered the majority of the forms at St. David's, Mr. D. Homfray was asked by Mr. Salter to examine the slaty beds which flanked the Harlech Mountains, and in a joint paper by Mr. Salter and myself to the Geological Society[1] Mr. Salter gives the general results in the following words: "Having faith in the continuity of the band, I had begged Mr. David Homfray, of Portmadoc, to employ his first leisure in examining the same horizon in the Ffestiniog country, a locality which had hitherto been neglected. He met with his usual good success; and found, not merely the same genera, but many species which we had discovered at St. David's. I think hardly any of the forms are distinct. There are *Anopolenus, Conocoryphe, Microdiscus, Holocephalus*, together with *Theca* and *Agnostus*, all, or nearly all, of the same species as those described in our paper. There is also a new genus of Trilobites which we have called *Erinnys*, distinguished by the great number of the body-rings, and this is also found both in North and South Wales. This identity of forms between localities so widely separated and on the same horizon gives us great reason to believe that the fauna is a marked and persistent one over large areas." In 1891 (Geol. Mag. p. 533) Prof. Lapworth announced the discovery by Mr. T. T. Groom of a *Paradoxides* occurring with *Ptychoparia, Obolella, Protospongia*, etc., at Nevis Castle and Comley, Shropshire. In a paper in 1875 in which I attempted to correlate the main zones which we had found in Wales with those which had at that time been made out in various areas on the Continent of Europe[2] I said that the "Western areas have a larger number of

[1] Quart. Journ. Geol. Soc., November, 1865.

[2] "The Physical conditions under which the Cambrian and Lower Silurian rocks were probably deposited over the European areas" (Q.J.G.S. vol. xxxi. p. 552).

orders, a greater number of genera, and, in the genera, show a greater number of varieties or stages of progression, than we find in any of the more Eastern areas. Many of these steps or species are wanting in the Eastern areas, and it is probable that they never reached so far, just as it is evident that many intermediate forms did not reach the Western areas. Many forms, as they fulfilled their mission, were lost on the way, and it is only the stronger and more marked varieties, which we now look upon as species, that were able to pass on. Minor changes may also have taken place even in very limited areas; but it is evident that the more marked species were tolerably persistent and became more generally distributed." It is a remarkable fact that all the evidence which has been accumulated of late years tends to prove that there is a very close resemblance between the succession of the sediments, and in the forms characterizing the faunas of the Cambrian rocks on both sides of the Atlantic Ocean. This seems to me to show, as I mentioned in my paper in 1875, that the earliest homes of these faunas in this portion of the northern hemisphere must have been in some intermediate basin, whence migration took place towards each continent, and it would also account for the larger number of species as we approach towards this basin and for the diminished number in the more distant areas. How far animal life had progressed, and how many types were then in existence, it is impossible to say, for those only which were suitable to the conditions then prevailing in any given area would migrate to that part. The Zones of Life, as we at present know them, are therefore mainly records of the periods of dispersion of certain forms from areas previously occupied by them. This is why our chronological sequence of organisms is not more often in accordance with what the theory of evolution may seem to demand. Generally the evidence of a gradual progression from lower to higher forms is clear enough; but the actual stages are not often found, owing to the probability that none of the areas at present known to us retained the forms sufficiently long, or supplied all the influences necessary, to produce very marked changes in the animal forms.

Upper Cambrian.

In the very excellent summary of the researches carried on in Wales given by Mr. R. Etheridge, in the Memoirs of the Geological Survey, vol. iii. (1881),[1] it is stated that M. Barrande, who paid a visit to this country in 1851 "for the express purpose of comparing his rich materials with our published and unpublished types," then recognised the "Lingula Flag" of Sedgwick as the exact equivalent of his primordial stratum" (Étage C). At this time the Middle Cambrian or *Paradoxides* fauna was entirely unknown in Britain, therefore the Upper Cambrian or *Olenus* fauna only could in any way be used for comparison. To M. Barrande, therefore, must be given the credit of first recognising the presence of this portion of the "Primordial zone" in Britain.

[1] See also the Presidential Address to the Geological Society 1881.

Soon after M. Barrande's conclusions had been announced, "Mr. Salter was directed by Sir H. de la Beche to re-examine a portion of the Lingula Flag series, with special regard to the fossil succession, and found that the group was divisible into three distinct zones, two in the Lower, and one in the Upper division." As characteristic of the Lower series, he mentions *Agnostus princeps*, *Olenus cataractes*, and *Lingulella Davisii*, of the next overlying series, *Olenus micrurus*, *Hymenocaris vermicauda*, and *Lingullela Davisii* in great abundance; of the highest, *Olenus alatus*, *O. scarabæoides*, *Agnostus princeps*, several species of *Conocoryphe*, *Orthis lenticularis*, and *Dictyonema ? sociale*. In 1860 Mr. Salter again visited North Wales, and with "the hearty and eager assistance of Messrs. Homfray and Ash," and the services of the Chief Collector of the Survey, Mr. R. Gibbs, was not only able to add to the number of forms, but also to trace the three divisions into several new areas. In 1867 Mr. T. Belt, in a paper on "Some New Trilobites from the Upper Cambrian Rocks of North Wales,"[1] subdivides the lowest series given by Mr. Salter, and points out that there are two horizons marked by distinct species of *Olenus*, *Olenus gibbosus* being characteristic of the lowest, and *Olenus cataractes* of the higher beds. In another paper, "On the Lingula Flags or Ffestiniog Group of the Dolgelly district,"[2] he gives the results of researches carried on by him during the previous three years in conjunction with Messrs. Ezekiel Williamson and J. E. Barlow, and says that "recent discoveries have shown that the group includes at least six zones of animal life, each distinct and separate." To the three divisions previously marked out by Mr. Salter he gives the local names of Maentwrog, Ffestiniog, and Dolgelly, and says that they "are both lithologically and palæontologically distinct. None of the Crustaceans pass from one group to another, and peculiar genera are found in each." Professor Phillips had previously discovered several species of *Olenus* in black shales on the western flanks of the Malvern Hills, and these beds Mr. Belt correlates with his Upper Dolgelly beds. Other fossils had been discovered in these rocks, near Malvern, by Dr. Harvey B. Holl, Dr. Grindrod, the Rev. W. S. Symons, and others. In the year 1877 Dr. C. Callaway published a paper,[3] in which he gives an account of a most interesting discovery by him of Upper Cambrian rocks in South Shropshire. The "Shineton shales," he there states, appear to him from the fossils to be of Tremadoc age; but he says that one new species of *Olenus* (*O. Salteri*) "is probably representative of our Lingula Flags," and also that the majority of the "species have an older facies than the Tremadoc; but the abundant occurrence of an Upper Tremadoc form, and of another Asaphid, points in an opposite direction." He then states "that the facts of the case so far as the fossils are concerned will be best satisfied by referring the beds to the age of the Lower Tremadoc," but suggests the probability of the "Shineton shales forming beds of passage between the

[1] Geol. Mag. Vol. IV. p. 294. [2] *Ibid.* p. 493.
[3] Quart. Journ. Geol. Soc. vol. xxxiii. p. 652.

Lingula Flags and the Lower Tremadoc." In the year 1882[1] Professor Lapworth gave an account of the discovery by him in the "Stockingford shales," near Birmingham, of "many of the most typical Upper Cambrian Brachiopoda and Trilobites," a list of which he gives as follows: *Acrotreta socialis, Obolella Salteri, Lingulella ferruginea, Kutorgina cingulata, Agnostus pisiformis, Lingulella Nicholsoni.*

In a paper in 1885[2] by Mr. J. E. Marr and Mr. T. Roberts is given an account of the discovery by them of fossils characteristic of the "Lingula Flags" in some "black iron-stained slates" which are "well seen near Leweston, Trefgarn Bridge, and Spittal Cross, in North Pembrokeshire. The species mentioned are *Agnostus pisiformis*, var. *socialis*, and *Olenus spinulosus*.

The "Tremadoc Slates" of Sedgwick were divided by Mr. Salter, in 1857, into a Lower and Upper series. The fauna was stated by him to be essentially Middle Cambrian (now Upper Cambrian), but showing a tendency to include some few types characteristic of higher horizons. "The species, however, are all distinct, even from those of the Arenig Group, and those of the Upper are distinct from those of the Lower Tremadoc."[3] In the report by Mr. Salter and myself to the British Association in 1866, we announced the discovery of Tremadoc beds, "or what we regard as such," near St. David's, for "lying as they do upon the true Lingula Flags, and under the Arenig or Skiddaw Slates, they can hardly be anything but Tremadoc beds." A list is given of the fossils which had then been discovered by us, but many additional forms were subsequently added to it. These were discovered during our continued researches, carried on with occasional very valuable assistance from Messrs. Homfray, Lightbody, Hopkinson, and Kershaw. The fossils, comprising a rich and exceedingly interesting fauna (in which the earliest lamellibranchs, encrinites, and star-fish up to that time discovered in Britain occurred), were described by me in the Quarterly Journal of the Geological Society for February 1873, and at page 42 I stated that "the palæontological evidence goes to prove that they (the Tremadoc rocks) are closely allied to, if not identical with, the lower portion of the Tremadoc rocks of North Wales," and that the "conditions under which these rocks at St. David's were deposited seem to have been intermediate between those of the shoal and shallow water of the Lingula Flag period and those of the deep sea which must have prevailed when the fine muddy deposits of the overlying Arenig slates were being thrown down. This intermediate condition must have been particularly favourable to the existence of life, and was doubtless one of the causes of the appearance at this time of such a varied and important group of organisms."

The boundary-line between the Tremadoc rocks at St. David's

[1] Geol. Mag. Dec. II. Vol. IX. p. 565.
[2] Quart. Journ. Geol. Soc. vol. xli. p. 476.
[3] "Catalogue of the Collection of Cambrian and Silurian Fossils contained in the Geological Museum of the University of Cambridge," 1873, p. 15.

and the overlying Arenig rocks was then mainly adopted owing to the discovery by us of very rich Graptolite zones in the overlying slates, and to the recognition by Mr. J. Hopkinson of over 20 species belonging to genera characteristic of the Quebec Group of Canada.[1]

In the Quart. Journ. Geol. Soc. for 1880, p. 237, there is an important communication from Prof. T. McKenny Hughes, in which it is stated that beds in Anglesey which had hitherto been "referred to the Caradoc are Tremadoc; that they are succeeded by Arenig." In these beds he found *Orthis Carausii*, and *Neseuretus Ramseyensis*, a characteristic Tremadoc form, and he states that "they exactly resemble specimens from the Tremadoc of Ramsey Island (St. David's) in the character of the rock and mode of preservation of the fossils."

Although I have had to limit my summary to that portion of the Lower Palæozoic rocks now usually classified under the name Cambrian, I think it must be granted that the researches carried on in these rocks during the past thirty years have been most fruitful in important results. During this period the doctrine of evolution has exerted a powerful influence on geological thought; and no one who can call to mind the state of our knowledge before that time can possibly deny that the influence has been for good. Of necessity, those who were working on the earliest known faunas kept this doctrine continually in view, and I believe there are few at the present time who will not admit that evidence in its favour has constantly increased in strength as the gaps in the succession were being filled up.

III.—Restoration of the Antillean Continent.[2]

By J. W. Spencer, Ph.D., M.A., B.A.Sc., F.G.S.

THERE have been many suggestions respecting a continental connection of the West Indies, but this is the first attempt made to restore the Antillean lands. It is based upon the slowly

[1] These, with many additional forms obtained by us from the Arenig rocks of St. David's, were afterwards described by Messrs. Hopkinson and Lapworth in the Quart. Journ. Geol. Soc. vol. xxxi. p. 632 (1875), and in the discussion of that paper Mr. Hopkinson said "that the dendroid forms are only known to occur in abundance in Britain in the Arenig rocks of St. David's, and that there are intermediate forms connecting British and American species which occur in rocks of more ancient date." He further remarked that he "did not consider the dendroid forms valuable for determining zones, species very nearly allied to those of the Arenig rocks being met with even in the Lower Ludlow rocks of Shropshire; but the Rhabdophora occur only in small zones, and wherever they are found they seem to hold an equivalent position. They are consequently valuable for stratigraphical purposes." In the same paper they give a Table "in which every species (obtained in the vicinity of St. David's) is referred to its exact position in the vertical series," and in page 639 they say: "Perhaps the most patent result of these researches is the circumstance that they clearly demonstrate that the Hydroida of these ancient rocks, so long shunned or misinterpreted by the systematist, are rapidly emerging from the obscurity which has enveloped them, and will perhaps soon stand side by side with the better understood Brachiopoda and Crustacea, as unerring exponents of the true geological age of the most widely separated rocks in which they are found."

[2] Abstract of a paper read before the Geol. Soc. of America, August 14th, 1894.

accumulating evidence of great systems of submerged valleys, or fjords extending from the commonly buried lower reaches of all the great rivers, upon the terrestrial deformation involved in the changes of level over large regions and upon the distribution of the characteristic forms of life. The present investigations confirm and amplify the history of the coastal plain of the northern continent.

The forms of the valleys of the southern Appalachian mountains and of the coastal plain were illustrated, showing that their characteristics are mostly due to the insidious action of rains and rills, producing different results according to the slope or elevation of the base-level of erosion. This study was introduced in order to compare the drowned *cañons* with the land valleys.

The gentle but varying amount of epeirogenic deformation has permitted of correlations which would have been prevented had the sharp orogenic disturbances of recent times prevailed over very wide areas.

The submarine valleys or fjords have been correlated into systems with their tributaries, and in all cases they connect with the partly buried land valleys. The continent is bordered by a sub-coastal plain from 100 to 300 miles wide, which is characterized by plateaux or terraces now submerged to even 3000 or 5000 feet, with the oceanic bed beyond depressed to 12,000 feet or more. Crossing these plateaux, the *cañons* reach to depths of thousands of feet, and terminate in embayments into margins of the continental shelves. The Gulf Stream occupies portions of three distinct valleys, exclusive of its tributaries, which have been only slightly modified on the cols between them. The drainage of the West Indian continent was almost entirely to the west, there being only two or three long valleys upon the eastern side of the Windward mass. The fjords reach to the bottoms of the Gulf of Mexico and Carribean Sea, whose beds are shown to have been recent land plains (except the Sea of Honduras, in part). The valleys of the existing rivers, often deeply buried near their mouths, are in magnitude proportional to their fjords beyond.

The analogy between the land valleys and the drowned *cañons* is so complete that the unqualified conclusion is reached that the fjords are evidences of atmospheric erosion to their depths (with perhaps one or two exceptions), or in other words there was an elevation of the region, as high as the fjords are deep, less the reduction by differential deformation, which is more or less determinable. Thus it appears that there has been a post-erosion subsidence to an amount from 8,000 to 12,000 feet, carrying down the Antillean plains to form the present sea-basins, and the high lands to form the islands.

The general Miocene depression of the whole region left only small islands, and during this submergence portions of the region appear to have sunk to abyssmal depths.

The Pliocene period was characterized by the connection of the two Americas by way of the West Indian bridge, part of which

was a high plateau as is Mexico and the Great Basin to-day. This was the first period of the formation of the great *cañons*, and the modern topographic features. But at the close of the Pliocene period there was a submergence of from 100 to 1300 feet below the present altitudes, with the deposition of from 100 to 260 feet of (Matanzas) limestones. During this epoch the connections with the Pacific Ocean were shallow.

The earlier Pleistocene days were characterized by a re-elevation of the continent with great erosion and the clearing out and extension of the older Pliocene valleys. The continental development was nearly the same as in the earlier Pliocene continental epoch.

In Mid-Pleistocene times the continent was again depressed, so that the West Indian islands were reduced to a much smaller size than at present, but not so small as during the subsidence at the close of the Pliocene days. These later deposits were mostly loams and gravels. Some minor oscillations are recorded in the terraces.

Again there was a slight elevation of from 100 to 300 feet as shown in the *cañons* which form the outlets of many harbours. Then followed the depressions that gave rise to the latest terraces, which have been recently elevated, as also the modern coral reefs. Some portions of the region seem to be sinking very slowly and others rising.

In the Miocene period there was free communication between the Atlantic and Pacific Oceans. This was cut off by the Pliocene continental elevation, but slightly reopened in the later Pliocene submergence. Again the Atlantic waters were driven back in the earlier part of the Pleistocene period, after which the later depression freely admitted the Atlantic waters, with probably a shallow connection with the Pacific Ocean for a short time. Since the Mid-Pleistocene epoch the gentle undulations have made no changes in the sea connections, but have only varied the breadth of the now slightly submerged coastal plains.

The physical changes appear to explain the occurrence of the greater number of the marine fauna of the Antillean region. In this abstract the Sea of Honduras has not been explained, but it may have been a basin from earlier times than the date of the Gulf and Caribbean basins. The physical history is in accord with the distribution of mammals. The late Miocene fauna of Florida could not have reached the islands, and in that region there is no known Pliocene fauna to be considered even on the adjacent parts of the northern continent. At the close of the Pliocene period the lands were reduced to a few very small islets, and the coastal plain of the continent was submerged. Then followed the continental rise with a rich Pleistocene fauna in Florida, and some forms are known in the islands, but their life was again cut off by the next subsidence, since which time the modern types of mammalian life of Florida have not been able to reach the islands. In short, the physical history seems to explain the disappearance of many mammals from the region, for with a continental change of altitude of from 8000 to

12,000 feet, and the general drowning of the Antillean continent, the animals became extinct alike on the continental margin and the islands.

The key to the physical evolution of the continent seems to be locked up in the West Indies, yet it appears simple. Where the studies will lead, it cannot be predicted. These are fundamental questions in terrestrial movements and continent-making; changes of ocean currents and climates; the production of glacial conditions, and the distribution of the inhabitants.

IV.—On a Series of Saurian Footprints from the Cheshire Trias (with a Note on *Cheirotherium*).[1]

By Osmund W. Jeffs.

EVERY geologist is familiar with the name of Storeton Quarry, which may fitly be termed the "home of the *Cheirotherium*," celebrated as being the scene of the earliest discovery in England of the fossil footprints, first described by Messrs. John Cunningham and James Yates in 1839.

Fifty years' study of these footprints has left their origin, so far as exact identification with any known animal is concerned, a matter of as much mystery as when Sir Richard Owen gave attention to the subject in his classical work on "Palæontology." All the evidence, in fact, which we have accumulated since that time has only brought us to a negative position, and taught us that the explanation first suggested by Owen, and thereafter copied into nearly all our popular geological text-books, is not entirely correct.

The forms described have all been obtained from the "footprint bed" at the Storeton quarries (with the exception, named below, of two specimens from Oxton Heath). This "footprint bed" is a thin stratum of sandstone, with seams of white clay, together some three or four feet in thickness, which is exposed at several points along the quarry excavations, where it may be traced for some distance. The geological structure of the quarries is fully described by Mr. G. H. Morton, F.G.S., in "The Geology of the Country Around Liverpool" (second edition).

I first refer to the well-known impressions to which the name of *Cheirotherium* was originally given by Dr. Kaup, under the idea that the tracks were of mammalian character. In the event of their being afterwards proved to be Saurian, the alternative name of *Chierosaurus* was proposed. The latter term, being the more correct—all the indications pointing to a reptilian origin of the footprints—has been adopted by the British Museum authorities (see "Catalogue of the Fossil Reptilia and Amphibia in the British Museum"), but it does not seem to have found its way into general geological literature, or into our local museums. In a paper read before the Liverpool Geological Association in June last, I described several specimens of this genus, among which were the following:—

1. Slab (No. 130) showing right-hand, hind and fore feet of

[1] Read at the British Association (Section C), Oxford, August 11th, 1894.

C. Stortonensis. Pentadactylate digits. Length of pes 7½ inches; length of manus 3 inches. All the digits are perfect. The two feet are close together, being less than 1 inch apart. The toes are narrow and tapering, the first showing the characteristic turning inwards, like a thumb. In all the true *Cheirotherium* impressions the digits radiate from a centre like those in an outspread human hand.

2. Slab containing the natural mould of the impression of a medium-sized footprint; pes about 8 inches in length. These moulds or hollows in which the animal impressed its foot into the sand are far more uncommon than might be imagined, and this is the only perfect specimen I have been able to obtain. Its preservation is evidently due to the sandy matrix. Most of the "moulds" occur in the soft clay which is intercalated in the footprint bed.

3. Genus indet.—Slab (No. 134) showing hind and fore feet of a smaller species, with narrow toes. Length of pes 3 inches; length of manus 1½ inches. The toes in this species all curve inwards, and are not separated, nor do they radiate as in *Cheirotherium.*

4. Slab (No. 142) showing rain-pittings and a remarkable median impression running in a straight line, which may be attributed to the track made by the point of a tail trailing on the ground.

Of impressions made by smaller species of Reptilia, the Keuper, both at Storeton and Oxton, presents several examples. With the exception of *Rhynchosaurus* itself, very little is known of these creatures; for, although a great number of bones have been found in the Triassic strata, not only of Europe but of America and South Africa, it is still a matter of difficulty to correlate the footprints with any known species of animals.

The difficulty in deciphering these small footprints is increased by the fact that several kinds of impressions are often found together on the same slab, in addition to the frequent superposition of one impression upon another, as the animals walked across the expanse of sand in various directions.

Among the specimens exhibited are examples of five species, all of which are probably the prints of small reptiles. The forms marked *b*, *c*, and *d* have not been previously recorded from Storeton.

5. (*a*) *Rhynchosaurus.*—Four well-defined digits, with occasional vestiges of a fifth digit, much shorter that the others, possessing short claws and curved inwards. There is sometimes the mark of a projecting spur at the back of the foot. Length of foot 1½ inches. The middle toe often extends beyond the others. It is difficult to distinguish between the fore and hind feet, and the impressions follow so closely that the successive tracks of the animal's march are not clearly defined. All the toes curve slightly in the same direction. These impressions frequently occur on slabs exhibiting the tracks of *Cheirotherium,* often being superposed on the actual imprint of the larger saurian.

6. (*b*) Genus indet.—Tracks of a smaller animal, ⅔ of an inch in length, with a more stubby foot, and very distinct claws on the digits; the first digit very short, often indicated by a mere point

where the claw has penetrated the sand; four distinct toes, probably had a rudimentary fifth. The digits do not display the same parallelism as in the specimens attributed to *Rhynchosaurus*.

7. (*c*) Genus indet.—A minute form, ½ an inch long, showing four digits, tapering to a point; no vestige of claws.

8. (*d*) Genus indet.—Three rather broad digits, with claws (? webbed). Not well defined; may be same as (*b*).

9. (*e*) Genus indet.—An oval impression, with concave terminated digits, four or five in number, and a hinder projecting spur (? Chelonian). Toes webbed.

10. Two slabs from Oxton Heath (found by Dr. Ricketts) covered with impressions of (*a*) *Rhynchosaurus*, and probably of those included under (*b*).

11. A large slab found *in situ* from the South quarry, Storeton, at Easter, 1894, by Mr. Norman Jeffs. Shows specimens of several varieties—the slender-toed *Rhynchosaurus*; the minute form (*c*), several tracks; the stubby form (*b*); and both the fore and hind foot of a similar species to No. 134, resembling the *Cheirotherium*, but of smaller size, and differentiated from that species by having the digits all pointing in the same direction.

Note on *Cheirotherium*.

The larger footprints known as belonging to the *Cheirotherium* have long been attributed, on the authority of Sir R. Owen, to one or other genera of Labyrinthodonts.

In a paper contributed to the Transactions of the Liverpool Geological Association, in 1889, by Mr. James Hornell, the author records an interesting series of investigations on Labyrinthodonts, chiefly from a biological point of view, and though he apparently accepts Owen's correlation—since he terms it "successful" (p. 67)—he shows very clearly that the *Cheirotherium* impressions do not coincide with the normal type of *Labyrinthodon*. For the "hand-footed kind, where the hind limbs by reason of their greatly increased size depart from the central type," Mr. Hornell proposes a separate classification in a sub-order. But it may be pertinently asked whether there exists any evidence from the skeletons of Labyrinthodonts, now so numerously discovered in the Coal-measures, Permian and Triassic strata, of this special type of *Labyrinthodon*?

Since Owen correlated the *Labyrinthodon* with the *Batrachia*, a great mass of evidence has come to light, through the researches of Burmeister and Fritsch in Germany; Professors Huxley, Seeley, and Miall in England; and Professors Cope and Marsh in America. It is now accepted that the *Labyrinthodon* was more akin to the Salamander or Newt than to the Frog. Indeed, the skeletons which have been obtained entire from the petroleum shales of Germany show none of the supposed frog-like affinities. The *Labyrinthodon* was, in fact, a primeval Salamander, the species varying in size from small creatures, 8 inches in length, to huge animals of eight or nine feet.

It is but fair to state that Owen recognised the footprints of

Cheirotherium as resembling those of a Salamander,[1] although he, at the same time, attributed them to a supposed Batrachian. In his restoration of *Mastodonsaurus*, from Coton End, Warwick, Owen judged by the simple relics—chiefly of the teeth, parts of the skull, an ilium and humerus—he found there; but our present knowledge of the structure of these animals (which has been most minutely and elaborately investigated by a Committee of the British Association, reported upon by Professor Miall) is founded upon material which did not exist when Owen wrote his treatise in 1842. Even now our knowledge of the limbs of Triassic species of Labyrinthodonts is imperfect, and thus an important link in the chain of evidence required to enable us to correlate the footprints is wanting. Nor are we helped much by studying the limbs of the Carboniferous species of these Amphibians; for, on the authority of Professor Miall, the corresponding parts of the fore and hind limbs of *Labyrinthodon* are very similar in form, and present no uncommon difference of size. This feature, it is very evident, does not agree with the fossil footprints of *Cheirotherium*; and the more we study the known forms of true Labyrinthodonts, the more we are driven to the conclusion that whatever was the mysterious animal by which the larger footprints at Storeton were made, it cannot be referred to any *known* species of Labyrinthodont.

V.—The Aptychus.

By Ernest H. L. Schwarz, A.R.C.S.

THE discovery of an Ammonite (*Oppelia subradiata*, Sow., from Dundry, now in the British Museum) with the Aptychus *in situ* closing the orifice, would seem sufficient to set all doubts at rest as to the true nature of that body, viz. that of an operculum.[2] Many of the writers on the continent, however, have not seen that specimen, which unfortunately is unique, and are inclined to attribute to the Aptychus other offices, because:—

1. It usually occupies a very definite position within the living chamber of the shell, lying in the middle of the outer edge, with its umboes pointing forward, and its rough surface outwards.

2. The complicated internal structure of the middle layer of the calcareous Aptychi proves them to have been formed beneath the epidermis, and were not therefore homologous with the opercula of other Mollusca, which are dermal in origin.

3. The Aptychus very seldom, either in shape or size, corresponds with the aperture of the Ammonite shell to which it was supposed to belong.

These objections are valid enough if they went to support any

[1] ". . . . in having the shorter toe of the hind foot projecting at a right angle to the line of the mid-toe." Miall considers this feature common to other orders of reptiles.

[2] See article by Dr. S. P. Woodward, F.G.S., "On an Ammonite with an Operculum in situ," "The Geologist," 1860, Vol. III. p. 328 (with a woodcut); also Dr. H. Woodward, F.R.S., Geol. Mag. 1885, p. 346, and "Student," vol. iv. p. 1, pl. i. fig. 12.

solid opposition explanation; but none can compete with the teaching of the Dundry specimen, and the objections can be very well answered, as I propose to do in the sequel.

Taking the objections in order:—

1. Of the many suggestions which have been offered as to the internal nature of the Aptychus, such as the shell of dwarf males residing in the mantle space, like those of some cirrhipedes, or the gizzard teeth, etc., three have gained greater prominence than the rest. The first of these is that put forward by Valenciennes, and recently elaborated by Steinmann,[1] namely, that the Aptychus was a structure attached to the funnel, and working like the shells of bivalves by means of ligaments situate along the hinge-line, thus strengthening that organ, and enabling it to eject the water with greater force; this, then, indicating a higher degree of organism in the funnel than that exhibited by the Nautilus, led Steinmann to the conclusion that the Ammonites were Dibranchiata, though, of course, he brings other reasons to bear on the subject; and from the general acceptance of Steinmann's conclusion, I suppose the idea of the Aptychus being a funnel-cartilage has many followers. A second theory is that put forward by Keferstein, Waagen, and von Zittel,[2] namely, that the Aptychus was the covering of the nidamental gland, the view being supported by the fact that those glands are usually thrown into ridges, similar to those of the Aptychus, in many recent Cephalopoda. The third is that of von Jhering,[3] where, relying

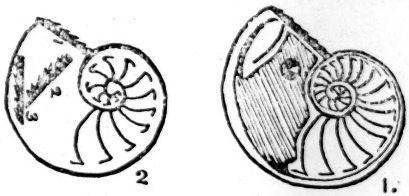

Fig. 1. Shows the Ammonite animal in the shell in the living resting position.
Fig. 2. Shows three stages of the position of the Apytchus after the animal has died.

upon the fact that the recent sepia has a nuchal cartilage situated at the back of the head, almost identical in shape with some Aptychi, he concludes, therefore, that the function of the Aptychus was to give attachment to the mantle; and, believing that the Aptychus, as it usually occurs in the living-chamber, retains the position it occupied in life, he concludes that the back of the Ammonite was turned outward, and the funnel internal (endogastric). Although Zittel, in his Palæontology, says that this view seems to have convinced nobody, yet it receives countenance from Haug's contention[4] that some Ammonites must have been endogastric, because the bay in the outline of the aperture, which was supposed to lodge the siphon, is internal in some genera.

[1] Steinmann, Berich. naturforsch. Gesell., Freiberg, vol. iv. pt. 3, 1889.
[2] Von Zittel, Handbuch der Palæontologie: Cephalopoda.
[3] Neues Jahrbuch, 1881, pt. i. p. 80.
[4] Gattung *Harpoceras*, Neues Jahrbuch, 1885, pt. iii. p. 596.

However, if we consider what would happen to an Ammonite when it had died and sunk in the ooze at the sea-bottom, we see that, supposing the animal exogastric like the living Nautilus, and the Aptychus functioning as a lid, the latter would necessarily have to take up its position in the place inside the chamber where we usually find it. For, being exogastric, the outer part of the animal would be occupied by the mantle space underlying the funnel; while on the inner side, the great muscles of the arms and head would present an impediment to anything entering the shell; so that, when the mud began to push in, the outer border of the operculum would be forced in first, and the whole thing would be turned on its axis, throwing the rough side downwards and outwards; and eventually, when the entire animal was decomposed, it would sink to the under surface of the body-chamber with its umboes looking forward, as we usually find it. Hence there is nothing in the fact that the Aptychus is usually found internal in fossils to preclude its having once acted as an operculum.

2. Though the horny Aptychus of *Goniatites*, *Arietites*, etc., might have been dermal in origin, the calcareous varieties most certainly cannot have been formed simply from the surface. But we never find rough bodies, such as the Aptychi belonging to the group *Imbricati* for instance, internal, unless they are suspended freely in a cavity, as the otoliths of fishes, or give support to other hard parts as in the vertebrate skull; and this, coupled with the apparent external uses of the Aptychus, drives one to the conclusion that, though primarily internal, it must have reached the surface by degeneration of tissues external to it. What these tissues were, it is impossible to say with certainty. Perhaps it was preformed in cartilage, for that tissue, as von Jhering has shown, sometimes becomes separated into square cells by means of fibres running through it; or more probably, the mass of muscle which constituted the hood, or conjoined tentacles, became surcharged beneath the sarcolemma with calcium carbonate, as happens in the case of man and hibernating carnivores, where it gives rise to gout; and the enclosed muscle bundle then decaying, left the cavity of the cell empty, or filled with secondary liquids, etc. Possibly, also, as suggested by the last simile, the Aptychus may have been formed at special resting periods during the life-history of the animal, for the organ has no means of growing when once it is fully formed; and to this cause may be due the small size of the Aptychus in some species, as compared with the normal aperture; that is, the lid, once formed, was retained for a long time without increment, though the animal itself went on growing as usual. In other cases it would become thrown off when the animal resumed active habits.

Although the structure of the Aptychus has many times been figured, especially in Meneghini and Bornemann's classical paper,[1] yet preparations that I have made show a feature that seems to have escaped the notice of other observers, namely, that the cells of the middle layer communicate one with another, and that their

[1] Atti. Soc. Toscan. di Sci. nat. 1876, vol. ii.

cavities open on to the outer surface by means of trumpet-shaped apertures (Fig. 3). This shows that there was something in the cells that required taking to the surface, and the suggestion of degenerate muscle supplies a clue to the meaning. The muscle would decompose slowly, having only a limited communication with the exterior, and gases would naturally force their way through the substance; but as the calcite of the Aptychus is peculiarly compact, it would have to make definite conduits for itself. This gas would probably be poisonous or evil smelling, so that, when the animal was resting during the elaboration of eggs, and the Aptychus applied to the opening, a natural defence would be secured against other predacious Mollusca, worms, and especially

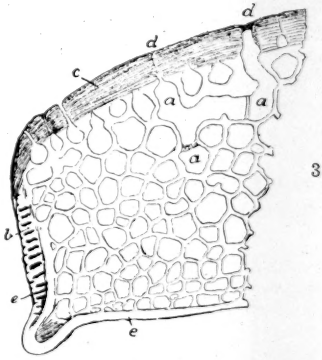

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Fig. 3. Section of *Aptychus lævis*, von Meyer, cut at right angles to the hinge-line in about the centre. *a*, *a*, *a*, communicating cells of the middle layer opening by two orifices on the exterior *d*, *d*; *b*, *b*, ligament pits? of the hinge-line; *c*, secondary outer layer of calcareous material; *e*, *e*, inner layer.

boring algæ, which usually manage to secure a foot-hold on resting shells, and which, as far as I have seen, the Aptychus is free from, though the pearly shells which contain them nearly always show abundant evidence of their ravages.

It is in this connection that I think we should look for the reason why the Aptychus is so frequently preserved, while no trace of the Ammonite shell is discoverable in the same beds. Fuchs[1] advanced the explanation that the shells consist of aragonite, and the Aptychus of calcite; but this difference would not sufficiently account for the phenomenon where the action of solvent waters went on for a great length of time. Also, although Sorby[2] and others quote the specific gravity of the Nautilus shell as 2·9 (aragonite), I have tried it with every possible care, both in the specific-gravity bottle, and the Joly-spring balance, and have found it 2·68 (calcite); the structure and properties of the Ammonite shell are so exactly similar to that of the recent Nautilus, that what obtains for the one holds good for

[1] Sitz. ber. d. k. Ak. d. Wiss., Math.-nat. cl. Bd. lxxvi. 1877, p. 329; also, Verhandl. d. k.k. geol. Reichsanst., Wien, 1879, no. 9, p. 186.

[2] Presidential Address, Geol. Soc., 1879, p. 30.

the other. But if the Aptychus contained gas when immersed in water it would be surrounded by a film of it, and thus would be rendered practically impervious to the water containing carbon dioxide in solution; while on the other hand, the shell tends to split repeatedly parallel to the surface, and thus draws the water into the cracks by capillary attraction, thereby exposing an enormous surface to the solvent action.

The outer layer of the Aptychus grows by simple deposition of calcite on the exterior, obscuring often the original outer ornamentation; thus in *Aptychus lævis*, von Meyer, the surface is perfectly smooth, with fine punctures all over it; but on cutting a section of it radially from the umbo (Fig. 4), the primary ridges are clearly seen, which would put it into the group *Imbricati*. Where this deposit on the outer surface is thick, as in the region near the umboes, the tubes communicating with the cavities of the cells of the middle layer are proportionately long. No trace of communications through the internal layer has been observed.

The hinge-line of the two valves shows narrow, deep cells filled in with a black material; von Meyer[1] has described them as ligament pits, though in my preparations they do not show any opening on to the exterior; the outer boundary however, may be secondary

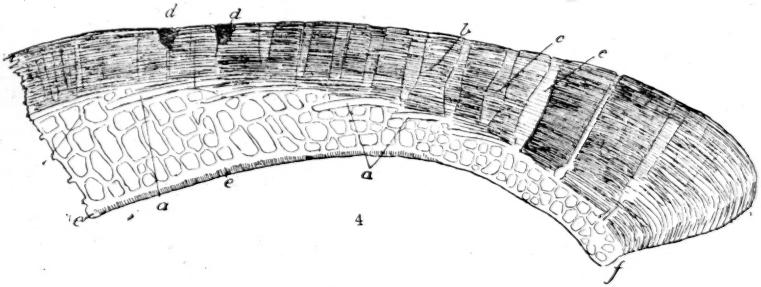

Fig. 4. The same specimen as in Fig. 3, but cut radially from the umbo. *a*, *a*, the primary imbricating outer layer; *b*, the secondary outer layer; *c*, *c*, tubules running from the cavities of the cells to the exterior; *d*, *d*, the orifices of the tubuli plugged up with black material (carbonized animal matter?); *e*, internal layer; *f*, the umbo.

in origin, but the specimens I have cut certainly did not owe their adherence to ligament, but to the tissues underlying the two halves during life.

In the group of *Aptychi nigrescentes* the inner layer is represented by a brilliant black coaly material, usually considered to be carbonized horny matter; but there is no reason why it should not be the decayed remnant of a derivative of muscle-tissue, viz. ligament.

Whatever be the nature of the tissues forming the Aptychus, the presence of tubuli reaching from the cavities of the cells to the exterior is absolutely opposed to the functional internal nature of the shell.

[1] Nova Acta Ac. Leop. Car. Nat. Cur., Bd. xv. No. 2, 1831; mentions a "starkstinkende Geruch" when the Aptychus is dissolved in acid.

3. In reference to the size of the Aptychus, it seems natural that it should not exactly fit the aperture of the shell, for if it did the animal would have to be continually opening the lid to obtain fresh water; while if there were abundant space between the operculum and the shell-wall, the animal could breathe continuously in a contracted condition, and the presence of "*stries creuses*" in the test of many Ammonites (produced by the tightening of the muscular walls, so that they were thrown up into little ridges which left their imprint on the inner shell) seems to necessitate the power of doing so. While, again, if the Aptychus were poisonous, as I have suggested, and not merely a passive protection, there would be no necessity for the orifice to be closely shut. At any rate, then, there seems abundant evidence that the Aptychus could perform useful functions as an operculum without having to fit the aperture exactly.

In conclusion, I have shown that the theories against the Aptychus being an operculum can be met with equally plausible ones in favour of that view; and the fact that the Aptychus is known in one specimen to have officiated in that capacity, ought to throw suspicion on the other theories.

NOTICES OF MEMOIRS.

ABSTRACTS OF PAPERS READ BEFORE THE BRITISH ASSOCIATION AT OXFORD, AUGUST 9–14, 1894.

I.—THE PROBABLE RANGE OF THE COAL-MEASURES UNDER THE NEWER ROCKS OF OXFORDSHIRE AND THE ADJOINING COUNTIES. By Professor BOYD-DAWKINS, F.R.S.

THE principle laid down by Godwin-Austen and Prestwich that the master or tectonic folds in the pre-Carboniferous and Carboniferous rocks are lines of weakness along which the newer rocks have been folded in later times, has been recently applied by Bertrand to the district of northern France. In the present communication the author proposes to see how far it can be used in the search after the buried Coal-fields of the counties of Oxford, Buckingham, Berks, and Wilts.

From the relation existing between the tectonic anticlines and synclines in the districts of South Wales, Gloucester, and the West of England, where they can be studied at the surface in the Palæozoic rocks, most important conclusions may be drawn as to the Coal-fields buried under the newer rocks in southern England. They are as follows:—

1. The Mid-Devon syncline, traceable eastwards until it cuts the sea-line near Bognor.

2. The North Devon anticline, which runs eastwards through the Vale of Wardour, past Salisbury, and along the anticline of the Weald from Petersfield to Dungeness.

3. The Mid-Somerset syncline, which sweeps eastward through the Vale of Bridgewater and Glastonbury, through the Chalk downs between Heytesbury and Hindon, to Haslemere. From this point

it is continued to the east through Tunbridge Wells and Tenterden to the sea to the south of Hythe.

These three folds have no bearing on the range of the Coal-fields in the drainage area of the Thames. The fourth, or Pembroke-Mendip anticline, and the fifth, or South Welsh syncline, are the two great tectonic folds which remain for consideration.

The Pembroke-Mendip anticlinal range, highly faulted and folded, is traceable westwards into South Ireland, and eastwards through Pembroke and the peninsula of Gower, to the south of Cardiff, through Weston-super-Mare and the Mendip Hills. Throughout this area it forms the southern margin of the Coal-fields. Near Frome it plunges beneath the Oolites. It is, however, clearly marked by the Upper Greensand anticline of the Vale of Pewsey, and by the Upper Greensand inliers of Ham and Kingsclere. Thence it passes along the line to the high downs past Basingstoke and Farnham to Peasemarsh, south of Guildford, where it is seen in an inlier of Weald clay. It is carried still further to the east by similiar inliers south of Westerham, and at Wateringbury and Maidstone. From Maidstone it sweeps to the south-east, through Otham and Ashford, arriving at the coast close to Hythe. In the eastern portion of its course it has, in my opinion, been the chief factor causing the south-eastern trend of the North Downs in the district of Maidstone. It forms also the southern boundary of the south-eastern Coal-field discovered in the boring at Dover, and of the Coal-fields of northern France and Belgium.

The South Welsh syncline, only two miles wide at St. Bride's Bay, in the anthracite district of Pembroke, widens out into the Coal-field of South Wales, twenty miles in width. As it approaches the upper estuary of the Severn it is represented by the outlying Coal-field of the Forest of Dean, and the three partially or wholly covered fields to the north of the Mendip Hills, distributed through an area measuring forty-five miles from north to south. The wedge-like syncline with its more or less connected Coal-fields continues to widen eastwards, its northern boundary being probably represented by a line drawn from the northern rim of the South Welsh Coal-field to the north of the Forest of Dean, and continued due east beneath the Secondary and Tertiary rocks to some point between Walton-on-the-Naze and the mouth of the Blackwater. It passes through Gloucester, Rissington in the valley of the Windrush, Blenheim, Kirtlington, Quainton, Luton, Bishop's Stortford, Dunmow, Braintree, and Colchester. The width of this great tectonic syncline between Colchester and Dover is about fifty miles, and it occupies nearly the whole of the London Tertiary basin, which, it must be noted, is of the same wedge shape, widening to the east.

The boring recently described by Mr. Whitaker at Culford, near Bury St. Edmunds, in which a slate rock, probably of Silurian or pre-Silurian age, was struck at a depth of 637 feet 6 inches from the surface, shows that in all probability that area is an anticlinal area. About forty-two miles to the south, in the deep boring at Harwich, the Yoredale shales come in. Both these points are, be it

remarked, to the north of the line in question. Both indicate a Palæozoic area in Suffolk and northern Essex older than the Coal-measures, and similar to that on the same meridian in South Wales and Gloucestershire which lies to the north of the western Coal-fields. We have, therefore, not merely a well-defined Pembroke-Mendip anticlinal forming the southern boundary of the Coal-fields both in the west and in the east, as proved by the south-eastern Coal-field at Dover, but also evidence of the continuation of the South Welsh pre-Carboniferous barrier of Hull, which forms the northern boundary of the visible Coal-fields due eastwards into Suffolk. It may, therefore, be reasonably inferred that similar Coal-fields, isolated from each other by tracts of older rocks, are to be found in the South Welsh syncline, where it lies buried beneath the Secondary and Tertiary strata. In other words, we may conclude that there are Coal-fields in North Wilts, in the counties of Berks, Oxford, and Buckingham, and the Tertiary basin of the Thames within the limits laid down above, and in a direction indicated in 1871 by the Coal Commissioners.

One such Coal-field, indeed, has already been discovered in a deep boring at Burford, near Whitney, in the valley of the Windrush. The discovery, however, has unfortunately not been followed up, and we do not know whether it is of wide east and west range, similar to that of South Wales, or of Bethune and Namur, or whether it is small and unimportant, like some of the smaller Coal-basins north of the Mendip Hills. It offers a sure basis for other deep borings, which might have the same industrial effect on Oxfordshire as those which have extended the range of the buried Coal-measures in northern France, ninety miles to the west of Charleroi, and converted a purely agricultural into a great manufacturing district. There is no practical difficulty arising from the depth at which the Coal-measures may be expected to occur in this region. At Burford they were struck at 1184 feet from the surface, and at Dover at 1113 feet below high-water mark.

The borings in the area of the London Tertiaries prove that the Palæozoic rocks are not buried to a greater depth than about 1200 feet below sea-level, and in Hertfordshire to as little as 796 feet. The most important collieries in England are carried on at depths ranging from 1500 to more than 3000 feet. The new light thrown upon the question of the buried Coal-fields by recent discoveries places it in a very different position from that which it occupied in 1871, when Godwin-Austen, Prestwich, and Hull gave their evidence before the Royal Commission.

The boring at Dover, revealing the existence of a valuable Coal-field, now offers a fixed point for further discovery in south-eastern England. That at Burford offers a similar basis for the proving of the Oxfordshire Coal-field. The many other wells and borings made in the area of London, and as far north as Bury St. Edmunds, also afford important information as to the northern boundary of the productive South Welsh syncline. The development of our mineral wealth is of such vast importance that it would be quite worth the

while of the Government to undertake a series of experimental borings, which would indicate the exact position of the buried Coal-fields. In the present state of the mining laws it is a task not likely to be undertaken by the private adventurer. It might, however, be carried out by the County Councils, or by a combination of land-owners, either with or without a compulsory rate, as the property would be benefited by the discovery of new fields. It is one of those objects of public utility which are especially worthy of the support of the British Association at this time and in this place.

II.—Stonesfield Slate. Report of the Committee, consisting of Mr. H. B. Woodward (Chairman), Mr. E. A. Walford (Secretary), Professor A. H. Green, Dr. H. Woodward, and Mr. J. Windoes, appointed to open further sections in the neighbourhood of Stonesfield in order to show the relationship of the Stonesfield Slate to the underlying and overlying strata. (Drawn up by Mr. Edwin A. Walford, Secretary.)

THE basement beds of the Great Oolite in the Midlands and in the south-west counties of England have been hitherto supposed to be well defined; for in all the records of the many writers on this geologic subdivision, to the Stonesfield Slate has been assigned the line of separation from the Fuller's Earth or Inferior Oolite, or, where the Stonesfield Slate is absent, as in the extreme west, to the Minchinhampton beds has been assigned the same position. Undue prominence has been given to so inconstant a set of beds as the Slate, as much from the ease with which fossils for its study have been collected as from the varied character of the fauna and flora found in it. From the days when the finding of the mammalian remains in the Slate called the attention of geologists prominently to it, every text-book of geology has found a place for it at the bottom of the Great Oolite limestones. Though, however, text-books and papers have defined the lower boundary of the Great Oolite so clearly, the officers of the Geological Survey in their work in the neighbourhood of Stonesfield found the lines so difficult to define that it became necessary, where the Slate had disappeared, to adopt an intermediate colouring, a kind of no-man's-land. Since then an argillaceous stratum, "the Rift bed," has been recognised as the lowest of the Great Oolite beds in the Banbury and Hook Norton area.

The endeavour of the work, for which the British Association made a money grant in 1893, has been to ascertain the thickness and composition of the beds underlying the Slate, for hitherto no account of these beds has been obtainable, Prof. Ed. Hull's record[1] of 70 feet being the only assumed thickness of the Great Oolite, and to this he adds 30 feet for the Inferior Oolite. Though their thickness seems to be over-estimated, no correction or account of a series of rocks so important has since then been made. Nearer Chipping Norton, however, Mr. J. Windoes, Mr. W. H. Hudleston,[2]

[1] Report Brit. Assoc. p. 82 (sections), 1860.
[2] W. H. Hudleston, Proc. Geol. Assoc. vol. v. No. 7.

and your Secretary[1] have worked at some of the debatable beds above the Clypeus grit, one of the highest of the Cotswold divisions of the Inferior Oolite. To the bulk of these beds has been given the name of the "Chipping Norton Limestone" by Mr. Hudleston, and though the beds have not been reached in the section, they may be seen in the lane sections and near the spring on the banks of the Evenlode, south of Stonesfield. Your Secretary in 1892–93 sank a shaft near Ditchley, Oxon, to find out the true position of the Slate beds there; but of this an account will be published elsewhere.

The progress of the work, so far, at Stocky Bank, Stonesfield, has consisted in scarping the bank for 33 feet, and in continuing the section by carrying a shaft of 20 feet in depth through the lower bank. The purpose of the work has been so far successfully carried out by showing the existence of 30 feet of rock with some thin clay courses below the Slate. These limestones and clays (see accompanying section) are of Great Oolite type. To reach the Clypeus grit will need an extension of time and work.

Your Secretary has, by the discovery of numerous species of corals on the ploughed fields on the bank top, been able to define the Coral bed (Rift bed)[2] so prominent a feature in the near section at Ashford bridge. Seventeen feet below the coral bed a course of Slate is met with, almost thinned out at that point, and only from 5 to 7 inches in thickness; the total thickness of it and the associated beds (10, 12, 13 of the section) being about 5 feet. The usual fossils, *Trigonia impressa*, etc., occur. In the lower limestones, 15 and 17, are greenish clay inclusions.

The great mass of buff limestone below the slate is almost unfossiliferous, and neither its mineralogical character nor its few fossils give sure evidence of its relationship to neighbouring beds.

Prominent in the lower half of the section is the breaking up of the calcareous series by small clay beds, and of these No. 23, with its dark compact clays, is in part made up of oyster-shell fragments. It contains numerous compressed shells, *Perna quadrata*, *Nucula*, etc., but washings of the beds yield hardly any microzoa. The limestone above the clay yields well-known Great Oolite shells, *Mytilus Sowerbyanus*, *Rhychonella concinna*, and *Ostrea Sowerbyi*. The shelly limestone below the clay is in part an Oyster lumachelle, and passes into a blue-hearted limestone with *Perna quadrata*, large *Cyprinæ*, *Corbula*, and *Macrodon*. Here, again, both petrological facies and fauna are dissimilar to any of our known Oxfordshire Oolitic rocks and, like each of the succeeding lower beds, should be classed as Great Oolite; one of the latter, a hard, very oolitic freestone, has also as distinctive a character.

In conclusion, it should be stated that though, when Prof. Ed. Hull reported to your Association at its Oxford meeting, thirty-four years ago (1860), the presence of seventy feet of Great Oolite limestone under the Stonesfield Slate, it seemed to be an over-

[1] E. A. Walford, "On the Relation of the so-called Northampton Sand of North Oxon to Clypeus Grit," Q.J.G.S., vol. xxxix. p. 235.

[2] E. A. Walford, Q.J.G.S. vol. xxxix. p. 230.

estimate, yet the result of the present investigation has been to prove the presence of an important and overlooked section of the Great Oolite, and to entitle place for it in future accounts of that subdivision. That Prof. A. H. Green doubted the existence of so great a series of beds as those quoted by Prof. Hull is proved by the absence of any account of them in his excellent memoir "On the Geology of the Country round Banbury, Woodstock, Bicester, and Buckingham," published in 1864.

Mr. James Windoes, Mr. Wilfrid Hudleston, Mr. H. B. Woodward, and your Secretary have also worked in later years at the determination of the equivalent of these lower Bathonian beds in the neighbourhood of Chipping Norton.

To his Grace the Duke of Marlborough, to the Right Hon. Lord Dillon, to Mr. John Barrett of Stonesfield, and to Mr. S. Shilson of Charlbury, the thanks of your Committee are due for aid in this and other relative work.

The probable extension of a lower division of the Great Oolite, great enough to entitle it to a place as a sub-formation, below the limit reached by us makes a continuance of the work a necessity for the right understanding of the Lower Jurassic rocks of Great Britain.

Section at the S.W. end of Covert, Stocky Bank, Stonesfield, Oxon, 1894.

		Ft.	in.
1.	Humus with limestone fragments containing *Nerinæa*, *Cryptocænia Prattii*, E and H, *Cryptocænia* sp., *Isastræa microphylla*, Tomes, *Isastræa limitata*, Lamx., *Isastræa* near to *limitata*, Lamx., *Thamnastræa Lyelli*, E. and H., and *Epismilia* sp. "Ritt Bed"	0	9
2.	Grey Marls with *Ostrea*, *Placunopsis*, and *Rhynchonella concinna*	4	0
3.	Fawn-coloured Sands and Marls—Oyster bed	2	0
4.	Grey shelly compact Limestone, weathering cream-coloured	6	0
5.	Hard grey Marls with *Rhynchonella concinna*	0	9
6.	Shelly Limestone	0	6
7.	Marl	0	2
8.	Limestone	1	3
9.	Marls with Oysters, etc.	2	6
10.	Limestone, shelly Oolitic and cream-coloured "Roof" of Slate	1	8
11.	Stonesfield Slate, "Top hard," compact, grey crystalline	5 in. to 7 in.	
12.	Soft fissile Sandstone "Pendle"	9 in. to 1 ft.	
13.	Limestone, coarsely fissile and Oolitic, with clay inclusions, concretions, black carbonaceous markings, and fragments of *Rhynchonella* and *Trigonia impressa*	2	0
14.	Marl, brown fissile and sandy	0	3
15.	Shelly Limestone, laminated and banded with clay inclusions in the upper part; fawn coloured with Oysters	2	3
16.	Soft fissile Sandstone with carbonaceous markings	0	5
17.	Limestone, compact, close-grained, fawn coloured, with carbonaceous markings and clay inclusions	7	6
18.	Limestone, close-grained, buff coloured	5	6
19.	Clay	1	6
20.	Limestone, compact, buff coloured	2	8
21.	Marl	0	4
22.	Limestone, white, shelly, and crystalline, with *Mytilus Sowerbyanus Rhynchonella concinna*, and *Ostrea Sowerbyi*	1	3
23.	Black Clay, crowded with *Placunopsis* in places, with *Perna*, *Nucula*, and *Ostrea*	1	7
24.	Shelly earthy Limestone, made up mainly of Oyster fragments, and passing into a brown, blue-hearted Limestone crowded with shells, *Perna quadrata*, large *Cyprina*, *Corbula*, and *Macrodon*	2	0

	Ft.	in.
25. Black Clay	0	11
26. Hard Oolitic Freestone, blue-hearted, made up of whitish Oolites in blue or brown base	2	0
27. Rubble	0	3
28. White fine-grained Limestone, with few shells	1	2

III.—On some Lacustrine Deposits of the Glacial Period in Middlesex. By Henry Hicks, M.D., F.R.S., F.G.S.

IN this paper the author refers to some deposits, consisting of stratified gravels, sands, and clay, varying in thickness from a few feet to over 20 feet, which are spread out over the plateaux of Hendon, Finchley, and Whetstone. They are frequently covered over by the chalky Boulder-clay with northern erratics; but seldom themselves contain other materials than those which could have been derived from the Tertiary or Cretaceous series in the south-east of England. No marine fossils of contemporaneous age have been found in these deposits, but remains of land animals occur occasionally in and under them. The author has found that their geographical distribution is much greater than has usually been supposed, and he has been led to the conclusion that they must have been deposited in a lake, in the Glacial period, whose waters attained to a height of nearly 400 feet above present O. D. This lake, he believes, occupied a considerable area in the south-east of England, and spread for some distance south of the Thames, but was dammed up on the east and west. As the lake became gradually reduced in size, lakelets were formed in the Thames Valley, and most of the stratified deposits now found there, except those in the immediate proximity of the present Thames and its tributaries, date back to that period. Man, however, lived in the valley before any of these deposits were thrown down, hence it is that the flint implements and the mammalian remains usually occur under or in the lower parts of the deposits.

IV.—On the Terraced Hill Slopes of North Oxfordshire. By Edwin A. Walford, F.G.S.

THE green slopes of many of the minor vales of North Oxfordshire are scored with parallel terraces or terraced banks, frequently of such regularity in depth of step and slope as to present to the mind any other origin for their formation than that of the every-day work of natural forces. They have been described as camps, entrenchments, and amphitheatres, and those of other districts Mr. Gomme has described, and has cited the many theories of their origin.

Mr. Walford first drew attention to the Oxfordshire and Warwickshire terraced fields in 1886,[1] and dealt at greater length with the subject in 1890.[2]

[1] E. A. Walford, "Edge Hill: the Battle and Battlefield," p. 24 (Banbury, 1886).
[2] E. A. Walford, "On some Terraced Hill Slopes in the Midlands," Journ. Northampton Nat. Hist. Soc., January, 1890.

He gives as causes of formation—

1. The downward creep of the surface and sub-surface soil.

2. The occurrence of the terraces upon one precise geologic line, the micaceous marls of the Middle Lias which come in below the Red Rock bed. The marls are porous and non-cohesive. On the slippery slopes the soil must creep. The rain and rain-wash loosen the light soil below and about the roots of the herbage and urge its movement downward. Terraces from an incipient stage, like an ordinary grass ridge, to minor and major terraced banks of varying regularity of form can be traced. Below these marls are depths of compact blue clay (the zone of *Ammonites margaritatus* if in near contact with the marls). A little below the point where the marls and clays meet is the line of water outflow. Along the line there is constant removal of marl by chemical and mechanical solution. The effect is the loosening and sliding of the land downwards and outwards. This pressure is aided by the weight of the overlying mass of rock, sometimes twenty-five feet in thickness.

3. Free passage of water through the rock and marl is necessary, for the Upper Lias clays have on the Oxfordshire terraced hills either been wholly stripped from the hill top or pushed back by atmospheric denudation. Regularly terraced slopes are not found on clay-covered hills; the appearance of terraces is coincident with the wearing away of the clay "roof."

The amphitheatre form of terraced land is always a valley head. The outflow of the stream—the valley-maker—marks ordinarily the base of the amphitheatre. More frequently the terraces of the valley head are small in slip and their curvature is broken. Such an instance is Kenhill, near Shennington. An instance of greater regularity of curvature and greater depth of step is the Beargarden, Banbury.

From the Edge Hill escarpment a fork of the Horton vale runs alongside Adsum Plantation, and makes what is known as Adsum Hollow. The terraces sweep in regular curves along the high banks of the stream, and where it joins the main vale to the north of Horley the steps are so prominent as to give the name of Steps Meadow to the ground. Gredenton Hill, on the Burton Darrett range, is very regularly and beautifully terraced on three sides.

The author does not attempt description of the Chalk hills or the lynchets of Dorsetshire. The sandy marls of the Dorsetshire Inferior Oolite have a composition approaching that of the micaceous marls of the Midlands, and reasons like those brought forward will no doubt prove their similar mode of formation.

REVIEWS.

I.—Palæospongiologie; von Hermann Rauff. Erster Theil. 5te und 6te Lieferung. Mit 17 Tafeln und 27 Abbildungen im Text. Palæontographica. Band xl. Stuttgart, 1894, pp. 233–346.

THE previously issued (1–4) parts of Dr. Rauff's elaborate Monograph on Fossil Sponges, which dealt with the general history, structure, and classification of the group, have already been

noticed in the GEOLOGICAL MAGAZINE.[1] The present issue begins the special portions of the work which treats of the characters and relations of the different genera and species, taking them in the order of their geological appearance. In these two parts the sponges from the Cambrian rocks, and a considerable number of those from the Silurian, are described in great detail, and in most cases both the sponges themselves and their minute and often intricate skeletal structures are figured either in the text or in the beautifully-executed plates, with striking fidelity. The majority of the forms are not new to science, but it may be said of many of them, hitherto only superficially described, that their characters are now made known for the first time. In several respects the sponges from the older rocks present greater difficulties to the student than those from the Mesozoic formations, for they are often less perfectly preserved, and the structures in some differ markedly from those of a later age; but these obstacles have been successfully overcome by the author, who has worked out the construction of their skeletons with much skill and patience.

From Cambrian strata but a small number of species are known, and these as a rule only by imperfect fragments. The Hexactinellid genus *Protospongia* is the most widely distributed form, but it is principally represented by detached spicules and small fragments of the mesh, which, as regards preservation, fall far short of those discovered by Dawson in the Ordovician strata of Métis. Lithistid sponges from the Upper Cambrian of the Mingan Islands are better preserved, at all events in the case of the remarkable *Archæoscyphia Minganensis*, Bill., sp., whose affinities to this group, which had been disputed by Bornemann, are confirmed by the author; another form, first described by Billings, is the *Nipterella paradoxica*. Dr. Rauff very properly excludes from the group a number of peculiar bodies from the Cambrian of New Brunswick, which Mr. G. F. Matthew had placed under sponges, apparently because they would not fit in with any other class of organisms, and also the doubtful *Leptomitus Zitteli*, Walcott, and a few others.

Coming now to the Silurian (in which the Ordovician is included by the author), we meet with a very considerable increase in genera and species both of Hexactinellid and Lithistid sponges. The Hexactinellids all belong to the Lyssakine division, and are referred to the following genera: *Protospongia*, *Dictyophytra* (=*Dictyophyton*, Hall), *Cyathophycus*, *Palæosaccus*, *Acanthodictya*, *Plectoderma*, and *Teganium*, n.g.

An interesting new form of this group, from the Wenlock Limestone of Dudley, is described under the name *Oncosella catinum*, n.g. et sp. Only one specimen of it is as yet known, and it is remarkable to find that it retains its form fairly complete and uncompressed, although its original siliceous skeleton has been altogether replaced by calcite. Yet other Hexactinellid genera of somewhat less regular build are *Pattersonia*, Miller (=*Strobilospongia*, Beecher), *Brachiospongia*, and *Amphispongia*. Dr. Rauff does not hesitate to rank this

[1] Dec. III. Vol. X. 1893, p. 524.

latter genus as a genuine Lyssakine Hexactinellid, in spite of its peculiar features. Of not infrequent occurrence, both in Silurian and in Carboniferous rocks, are the bundles of spicular rods which anchor the Hexactinellid sponges to the sea-floor; they have been variously named according to the different opinions held about them; thus M'Coy and Portlock considered them as annelid tubes, and placed them under *Serpula*; subsequently M'Coy placed them in a distinct genus, *Pyritonema*. For similar spicular bundles in the Carboniferous rocks associated with normal Hexactinellid spicules, von Zittel used the generic term *Hyalostelia*. It is quite possible that these bundles may have belonged to different species and genera of sponges, and Dr. Rauff proposes to employ M'Coy's name for Silurian, and von Zittel's for Carboniferous specimens. But until it can be proved that the later ones belonged to another genus than the earlier forms, these similar objects cannot rightly be placed under two genera, and only one of these two names can therefore be retained.

The Ordovician and Silurian Lithistida probably were more numerous and important at this epoch than the Hexactinellida. One of the principal families is that of the Astylospongidæ, which, with the Hindiadæ, is included by the author in the tribe Eutaxicladinidæ. In this group the arrangement of the spicules and their mode of attachment to each other to form the skeleton are of a very complicated character; theoretically, according to the scheme of the author, where the rays of the spicule are simple, they are so grouped as to form the outlines of a series of rhombohedra. But as one or more of the rays may be in duplicate, the regularity of the theoretical plan is but seldom apparent in actual sections of these sponges. From an examination of a large number of American and European specimens of the Astylospongidæ the author has discovered that the European examples and those from Waldron in Indiana are characterized by smaller spicules and a closer skeletal network than exist in the forms from Tennessee and Canada, and though it is acknowledged that these latter belong to the same respective genera as the former Dr. Rauff proposes to distinguish them by employing a different generic term; so that, for instance, the Tennessee specimens are placed under *Astylomanon*, and the corresponding European forms remain under *Astylospongia*. We doubt very much the advisability of this proceeding, in view of the author's admission that the Tenesseean and Canadian Astylospongidæ belong to the same genera as the European. On the other hand, we quite agree with the author in dividing up the forms hitherto placed under *Astylospongia*, retaining this name for the typical *A. pramorsa*, Goldfuss, sp., which has a definite cloacal depression, and proposing two new genera, *Caryospongia* and *Carpospongia*, for the specimens in which there is a different arrangement of the canal system.

The structure of the skeleton in the genus *Hindia*, which is made the type of a new family, is stated to be in near relationship to that of the Astylospongidæ. Both the American and European examples are referred to a single species.

In the Appendix the author supplies some omissions in the catalogue of the literature previously published, and continues it down to the end of 1893, thus placing the students of fossil sponges under additional obligations. G. J. H.

II.—Papers and Notes on the Glacial Geology of Great Britain and Ireland. By the late Henry Carvill Lewis, M.A., F.G.S.; Professor of Mineralogy in the Academy of Natural Sciences, Philadelphia, and Professor of Geology in Haverford College, U.S.A. Edited from his unpublished MSS., with an Introduction by Henry W. Crosskey, LL.D., F.G.S. (London and New York: Longmans, Green, and Co. 1894.)

SCIENTIFIC ideas which engage attention show a remarkable parallelism to the history of characteristic species in a geological formation. Sooner or later, after their first appearance, they attain an extraordinary development, displacing the other ideas or species which had previously been familiar; then become less important, and eventually settle down side by side with the older types of life or thought, which often come back again, to share the field with the interloper, which has found its true position.

The studies of the elder Agassiz among the glaciers of the Alps, gave an impetus to observation of the nature of glaciers and the work they do, which took nearly thirty years to develop. And subsequently the observations of the late Sir Andrew Ramsay, and the exposition of Sir Archibald Geikie, led to an endeavour to discover the extent to which the surface of the earth has been shaped by land-ice, which has now reached its full expression. On a recent occasion we drew attention to the way in which Sir William Dawson, preserving the old traditionary iceberg theory of the origin of glacial drift, had endeavoured to apply it in explanation of the glacial phenomena of North America, assigning a subordinate place to the moraines produced by terrestrial glaciation. We have now the converse story in the record of observations made by the late Professor Carvill Lewis, on the Glacial Geology of the British Islands. Everyone who knew Mr. Lewis will recognise that no more brilliant exponent of the glacial theory has been heard in the present generation; and whatever may be the place which his contribution to glacial geology eventually occupies in the history of science, it arrests attention by the boldness of conception which directs it, and by the breadth of observation of fact, which endeavours to apply to this country the mode of interpretation which he had already used in concert with other geologists in the United States.

The work was, unfortunately, little more than begun, and the memorial volume which we now notice includes but eighty pages of completed papers, and consists largely of the contents of notebooks, which are rather a diary of observations of glacial phenomena as they were seen than a digest, or interpretation. The late Dr. Crosskey has, however, in his introduction, endeavoured to indicate the main points which these extensive and original observations suggest as worthy of examination. Mrs. Lewis contributes a short

historical account of her husband's work. Professor Lewis believed that the division of the drift into Lower Boulder-clay, Middle Glacial sands, and Upper Boulder-clay, has yet to be established; and thought it probable that the Upper and Lower Boulder-clays in Lancashire may be the same deposit. Science is always in danger from hasty generalization of local phenomena; and those who are familiar with the Eastern Counties sections of the Upper Boulder-clay have probably always held that the three-fold division of the drift is essentially local, and that there has never been any demonstration of its universality.

Professor Lewis called attention to the fresh-water origin of many deposits regarded as glacial, pointing out that when the courses of rivers were dammed by advancing or retreating ice, morainic lakes would be formed, in which icebergs would float; and as a necessary corollary he concluded that areas free from glaciation existed in between the glaciers. He endeavoured to define these glaciated areas by tracing their terminal moraines, and maintained that every glacier could be defined by this evidence in the time of its maximum development. A glacier may form a terminal moraine, but if the history of the glacier be a story first of augmentation and then of diminution, the retreat of the glacial moraine may give rise to appearances which are not quite in harmony with the theoretical position of the parent ice. There can be no doubt that enormous masses of Boulder-clay have been denuded since the Glacial period, and the residue of the boulders is only to be found in post-Glacial deposits. And one of the problems of the future, as of the past, is to discover the relation of the snow waters upon the surface of the land to the erosion of the Boulder-clay. For it is always towards the river basins that the clayey matter disappears, and the Boulder-clay passes into a hill gravel which shows some evidence of water-action. For a long time a submergence in the middle of the Glacial period had been looked upon as practically demonstrated, but of this submergence Professor Lewis found at first no evidence, or only such evidence as would imply a submergence of 100 feet on the east coast, and 150 feet on the west coast of England.

The shell beds in the Boulder-clay which occur at great elevations were regarded as having been pushed up bodily out of the Irish Sea into the positions in which they are found.

The fossiliferous deposits at a height of 400 to 450 feet, he supposed to be transported by glaciers which formed an ice-dam, helping to enclose an extra morainic lake; and in the same way the beds at Moel Tryfaen are regarded as examples of glacial transport. There is some appearance of Professor Lewis having arrived at the conclusion that there was a second and older Glacial epoch on the evidence furnished by the sections at Frankley Hill and California, near Birmingham, between the 500 feet and 900 feet levels, where he found great abundance of Welsh felsites and slates. Since the first Glacial epoch he believed great erosion to have occurred before the second Glacial period. He remarks that the Lower Till at California, if not made by a glacier, was made by

water close to the end of a glacier. Hence the whole question of subdivision of the Glacial period is practically left in the position in which Professor Lewis found it, and the criticism is the history of his own increase of knowledge.

The hypothesis of moraines, defining extra morainic lakes, in the middle and east of England, which Professor Lewis introduced, appears to rest essentially on the further hypothesis that the seas were filled with glacial ice, which prevented the escape of fresh water from off the land. Yet we are not aware of any evidence that the Cromer Boulder-clay was deposited in fresh water, as Professor Lewis supposes. Marine shells, especially *Cyprina* and *Tellina*, abound in the Cromer Boulder-clay, though they are mostly broken, and contemporary marine shells occur as far south as Ely, and this may be taken as evidence of water transport; but in view of the southward extension of the Boulder-clay in the Eastern Counties, it is difficult to find in it proof of a fresh-water origin.

The hypothesis of extra morainic lakes in which icebergs moved, does not appear to differ substantially from the older hypothesis of iceberg deposition of Boulder-clay as held by Phillips, Sedgwick, and many early observers, and the difference between Professor Lewis and them is rather of degree than of kind in interpretation of the facts.

The notebooks of Professor Lewis are a record of observation, never intended for publication, which will lead to useful work, in following up the indications given of facts observed at points, which are all carefully shown upon his maps. About 80 pages of these notes are given to Ireland; and the English notes are grouped geographically, dealing with Durham and Northumberland, Yorkshire; Lancashire, Cheshire, and the Midland district; the valley of the Severn; the east of England; the south of England, Wales; together with many notes on illustrative subjects. No small part of these notebooks is occupied with references to the literature of the subject, and the author's notes on localities described by previous observers.

The volume is illustrated with several maps showing the distribution of glaciers in North America and the British Islands; and about 80 woodcuts, which are mostly diagrammatic records of sections. There is an appendix by Mr. Percy Kendall, giving observations on the Manchester Ship Canal, on Lancashire and Cheshire glacial phenomena, and other subjects which he examined in company with Professor Lewis. Mrs. Lewis throughout has contributed notes in elucidation of her husband's work. The volume is excellently printed; but is, unfortunately, without an index.

III.—The Seismological Journal of Japan, Vol. III. 1894 (corresponding to Transactions of the Seismological Society): Edited by Prof. J. Milne, F.R.S. pp. 106, Five Plates.

Contents: (1) F. Omori: The Eruption of Azuma-san, pp. 1–22. (2) J. Milne: Seismic, Magnetic, and Electric Phenomena, pp. 23–33. (3) E. von Rebeur-Paschwitz: Description of an Apparatus for recording by Photography the Motions

of Horizontal Pendulums, pp. 35–54. (4) J. Milne: A Note on Horizontal Pendulums, pp. 55–60. (5) H. Darwin: A Bifilar Pendulum, pp. 61–63. (6) J. Milne: A Note on Earth Pulsations and Mine Gas, pp. 65–69. (7) F. Omori: On After-Shocks, pp. 71–80. (8) E. J. Pereira: Record of Yokohama Earthquakes, 1890–1894, pp. 81–86. (9) J. Milne: Velocities of the Earth Waves, pp. 87–89. (10) M. Daubrée: La Cause des Tremblements de Terre, pp. 91–106.

The increasing attention paid to the study of earth-pulsations is strikingly shown in this new volume. Five out of the ten papers are indeed more or less connected with the subject. Prof. Milne (4) describes a modification of his conical pendulum, one of the least expensive instruments used for their investigation. Dr. von Rebeur-Paschwitz (3), who has done so much excellent work with the horizontal pendulum, gives many practical details of the greatest service to those engaged, or about to engage, in this fascinating study.

In the other papers, Mr. F. Omori (1) describes the eruption of Azuma-san in 1893, and proves that the conical holes surrounding the crater were produced by falling stones. Professor Milne (2) concludes that we do not yet possess any certain evidence of a physical connection between earthquakes and electric and magnetic phenomena. Mr. Pereira continues his useful list of Yokohama shocks.

Mr. F. Omori (7) discusses the relative frequency of the after-shocks of the great earthquakes of Kumamoto in 1889, Mino-Owari in 1891, and Kagoshima in 1893. Every strong earthquake is invariably followed by a few weaker shocks; a destructive earthquake may be succeeded by even hundreds or thousands. For instance, during the two years after the Mino-Owari earthquake, as many as 3364 after-shocks were recorded at the Gifu meteorological station. Of these, 11 were violent, 97 strong, 1809 weak, 1039 slight, and the remaining 408 merely sounds. Ten of the violent shocks occurred during the first four months, the strong shocks all within the first thirteen months, and the weak ones all within the first twenty months. Towards the end only slight shocks and sounds were observed. Curves are drawn showing how the after-shocks gradually became less frequent. Roughly rectangular hyperbolas, they at the same time exhibit several maxima and minima, corresponding to periodic fluctuations in seismic frequency. Mr. Omori reckons that after a lapse of about ten years, the residual effect of the Mino-Owari earthquake will be so far reduced that there will be only one weak shock a month.

Lastly, M. Daubrée (10), noting the usual classification of earthquakes into volcanic (due primarily to the action of steam) and non-volcanic (connected with fractures in the earth's crust), and referring to the frequent occurrence of after-shocks, endeavours to trace both classes to the same origin. "Les tremblements de terre des régions dépourvues de volcans," he concludes, "paraissent dus aux effets d'un sorte d'éruption volcanique qui ne peut aboutir jusqu'à la surface, et semblent dépendre, aussi bien que ceux des régions volcaniques, d'une cause unique: la vapeur d'eau, animée de la puissance énorme qu'elle acquiert dans les profondeurs de la croûte terrestre."

C. Davison.

IV.—Zur Paläozoischen Flora der Arktischen Zone, enthaltend die auf Spitzbergen, auf der Bären-Insel, und auf Novaja Zemlja von den Schwedischen Expeditionen entdeckten Paläozoischen Pflanzen. Von A. G. Nathorst. Mit 16 Tafeln. Kongl. Svenska Vetenskaps-Akademiens Handlingar. Bandet 26, No. 4, pp. 80. (Stockholm, 1894.)

On the Palæozoic Flora of the Arctic Zone, comprising the Palæozoic Plants Discovered by the Swedish Expeditions on Spitzbergen, Bear Island, and Novaya Zemlya. By Dr. A. G. Nathorst.

THE occurrence in Spitzbergen of plant remains of Palæozoic age was first made known by Roberts in 1838; several subsequent Swedish geological expeditions also obtained them, both from Spitzbergen and from Bear Island, and the collections were described by the late Professor Heer. The last Swedish expedition, in 1882, under the leadership of Nathorst and de Geer, discovered Carboniferous plants in several new localities in Spitzbergen, and also for the first time they found plant remains in the Devonian rocks of Liefde Bay. They further ascertained that the true position of the Carboniferous plant-bearing strata of Roberts' valley, which had been described as above the marine Permo-Carboniferous formation, was beneath this series, its apparent position being due to an inversion of the beds. The present Memoir contains descriptions and figures not only of the newly-discovered plants, but of those previously collected and worked out by Heer, the originals of which, now preserved in the Stockholm Museum, have been revised by Dr. Nathorst, with the result that many are shown to belong to quite other groups than those in which Heer had placed them.

Taking first the plants from the Devonian or Old Red Sandstone rocks of the Liefde Bay series of Spitzbergen, it appears that they occur on two horizons—a lower, in which only fragmentary remains of a form resembling the *Psilophyton* of Dawson have been found; and a higher containing remains of *Lepidodendron, Bergeria,* and *Bothrodendron,* and also the leaves of a probable Gymnosperm, named *Psygmophyllum Williamsoni.* The plants are too fragmentary to be compared with the Devonian of other regions, but they show a relationship to the succeeding Lower Carboniferous flora.

The stratigraphical relations of the beds yielding the Carboniferous plants on Spitzbergen have not yet been satisfactorily determined. It is certain that they are below the marine Permo-Carboniferous series, but hitherto the existence of the Carboniferous Limestone has not definitely been made out, though it is possible that it may be represented by the *Cyathophyllum*-limestone. The new forms from the Carboniferous include species of *Sphenopteris, Cardiopteris,* and *Lepidodendron.* The forms described by Heer as *Cordaites* and as leaves of *Rhynchogonium* are considered by Nathorst to be unusually large stems of fern fronds. A comparison of these Carboniferous plants with those from other areas shows a very close resemblance with the flora of the Culm and that of the Bergkalk on the continent,

and equally so with that of the Calciferous Sandstone in Scotland, so that it may justly be considered a Culm flora. It has no special relation with the Old Red Sandstone flora, and therefore Heer's name of the "Ursa-Stufe" is not applicable to it. One of the remarkable features of this flora is the large size of the Ferns, *Lepidodendra* and *Stigmaria*, which show that the climate of the Lower Carboniferous epoch in Lat. 78½° N. must have been equally as favourable to plant life as that of the European continent at the same period.

Coming now to the Palæozoic flora of Bear Island, Dr. Nathorst modifies very materially Heer's determinations of the plants collected by Nordenskiöld and Malmgren. Thus, for instance, he doubts the occurrence of genuine *Calamites*, many of the specimens referred to this genus really belonging to *Knorria*, and one is provisionally placed as a new genus and species, *Pseudobornia ursina*. Several species of *Bothrodendron* are also present; one of these is identical with *B.* (*Cyclostigma*) *Kiltorkense*, Haughton, from the Old Red of Ireland. Many specimens placed under *Knorria* prove to be fragments of *Bothrodendron*. There is, further, no ground for supposing that *Lepidodendron Veltheimianum* occurs on Bear Island. The flora of this island is very distinct from that of the Lower Carboniferous of Spitzbergen, for with the exception of *Stigmaria ficoides* all the species are different; and it is equally as distinct from the Devonian flora of Spitzbergen. The author considers that it is intermediate between the Devonian and the Lower Carboniferous, and that the name *Ursa flora* may be retained for it.

Very little remains to be said respecting the fragmentary plants discovered by Nordenskiöld on Novaya Zemlya. The shales containing them are above the Permo-Carboniferous deposits, but the horizon they represent has not been determined. The plants were rightly referred by Heer to *Cordaites*, but on revision only two of the species described by him can be maintained. G. J. H.

V.—Étude sur les Variations du Spirifer Verneuili. Par J. Gosselet. Mémoires de la Société Géologique du Nord. Tome IV. Mém. I. pp. 61, Pls. I–VII. (Lille, 1894.)

A Study of the Variations of *Spirifer Verneuili*. By Prof. Jules Gosselet.

THE well-known and very widely-distributed Upper Devonian Brachiopod, *Spirifer Verneuili*, Murch. (=*S. disjuncta*, Sow.), is one of the commonest fossils of the Frasnien series in the North of France and Belgium. It is said to occur in the Eifélien and the *Stringocephalus* beds of the Middle Devonian, but the author considers that it makes its first appearance in the upper portion of the Givétien limestones. It reaches its greatest development in the Frasnien series and in the next higher Famennien series it is also very abundant. Here it comes into competition with *Cyrtia Murchisoniana*, and apparently gains the mastery; but in the higher beds of the series it becomes less common, and finally it disappears

before the end of the Devonian. The forms of this species are extremely variable, and Professor Gosselet gives in this Memoir the results of the study of numerous specimens, more particularly of those occurring in the Schistes de Barvaux, where it is especially numerous and well preserved. Detailed measurements of a large series of forms show important variations in nearly every feature of the shell, and the only constant character is the simple form of the ribs on the lateral or winged portions. The extreme variations are connected by a crowd of intermediate forms, and in the course of development the same individual may pass from one variation to another. There can, therefore, be no question of varieties in a zoological sense, and the author arranges the various modifications into groups of forms, six in number, taking as a basis the proportion of the width of the shell to the length of the smaller valve.

The author considers that *S. Verneuili* finally dies out without giving rise to another species; for though there are no extreme differences between it and such forms as *S. attenuatus* and *S. Mosquensis*, there are yet no intermediate forms known to indicate that it may be the ancestor of these latter. Discussing the question of the name properly belonging to the species, that of Murchison is adopted as, on the whole, having the best claim to priority.

To all interested in the question of Brachiopodal development the carefully worked out details in this Memoir, and its abundant illustrations, should prove highly valuable. G. J. H.

CORRESPONDENCE.

ORIGIN OF THE YOUNGER RED ROCKS.

Sir,—In his very interesting paper "On the Younger Red Rocks," my friend Dr. Irving professes himself to be more than ever convinced that the pebbly sandstones of the Bunter—such as those in Notts—consist of Triassic *sandbanks* deposited in narrow *tidal* seas, and "the great pebble beds of the Warwickshire and Budleigh Salterton type" are "the 'Chesil banks' which formed the shore equivalents of the sandbanks."

This is a matter on which I thirst for knowledge. Will he then kindly inform me: (1) What instances of marine conglomerates are known in which length, breadth, and thickness are simultaneously great? As a rule, the zone on which ordinary shingle is deposited extends but a few feet vertically above high-water mark, and not many below it. These conditions must somewhat restrict its breadth, and still more its thickness. Banks of the "Chesil" type can attain a greater thickness (though I should be glad to hear of one which came near or exceeded 100 feet), but they are comparatively narrow. (Mr. H. B. Woodward states that the Chesil Bank at Portland is 200 yards wide and 42 feet high.) But, according to Mr. Ussher and other authorities, the length and breadth of the area occupied by the Budleigh Salterton pebble bed is measured by miles, and its thickness varies from 50 to nearly 100 feet. The pebble beds in

the Midland Bunter must have extended over a large part of Staffordshire (interruptions being mainly due to faulting or denudation), and they have trespassed on the neighbouring counties. Their thickness sometimes come near, if it does not exceed, 300 feet, and very commonly is over 100 feet.

(2) How he explains the fact that the Triassic pebble beds present such a close resemblance to the *nagelfluh* of the Alps, and to the great gravel beds of later date which overspread the lowlands on both sides of that chain, while it is difficult to find a parallel for them among beds undoubtedly marine. I asked these questions in 1890, but failed to obtain an answer, so I am obliged to repeat them.

T. G. Bonney.

THE SOUTHERN DRIFT.

Sir,—In this month's number of the Journal of the Anthropological Institute, p. 45, there is a statement of so misleading a character that I cannot pass it over without comment. In speaking of the Hill Gravels of Berkshire, Mr. O. A. Shrubsole says: "this extensive deposit is composed of the Southern Drift of Phillips and Prestwich." Anyone reading this would suppose, as he gives precedence to the late Prof. Phillips, to whom I have not referred in my paper on the Southern Drift, that I had failed to make acknowledgment to him as the discoverer thereof. Such an impression I am anxious at once to remove. I was at a loss to conceive what foundation Mr. Shrubsole had for this statement. On turning to Phillips' "Geology of Oxford and the Valley of the Thames, 1871," I find at p. 460 the following paragraphs. After speaking of the "operation of a great flood, a deluge, coming from the north, north-west, and north-east," bringing down spoil of the Midland Counties into the Valley of the Thames at Maidenhead and at Kensington, Prof. Phillips says: "Looking at the distribution of foreign drift in the country under review, we find evidence of abundant currents from the north, which brought plenty of gravels on the western side, but no Boulder-clay; and plenty of Boulder-clay with some gravels on the eastern side; while in the middle space there are traces of currents from the south transporting *flints and Sarsen-stones*." A diagram accompanies this description showing flints and *Sarsen-stones* from the Chalk hills, apparently of Kent, striking in between the north-west and north-east drifts. He then goes on to say how this might have been effected by the agency of ice. This is all that Professor Phillips says of the composition of this drift. He does not even mention the term "southern" in the text; but in the index attached to the word "drift" are the words "northern" and "southern," used, I presume, merely as antithesis. No definition of age nor superposition is attempted; and, be it observed, surrounded as the Thames basin is on all sides by Chalk ranges, flints and *Sarsen-stones* are of themselves no sufficient evidence of direction of their source.

Long before I had formulated my ideas respecting the Southern Drift, I often had the opportunity of discussing with my old friend

and predecessor, Professor Phillips, the Drift beds of the neighbourhood of Oxford and the Thames Valley. Beyond the fact of the occurrence of flints in the Thames Valley, he was not aware of the widespread distribution of *chert* from the Lower Greensand on the higher hills of the Thames district, on which I mainly based my hypothesis of the Southern Drift. In fact, at that time, no one had recognised this chert *débris*, or if it had been noticed the fragments were spoken of as *Sarsen-stones*.

So far back as 1847, in "The Ground Beneath Us," after speaking of the flint gravel of the Thames Valley, I say: "It must have been from some distant spot that the materials of this gravel had been derived. . . . . The nearest place . . . . is in the range of hills passing by Croydon and Epsom, a distance of six to ten miles southward from Clapham." Again, "Whatever may have been the cause of this exceptional phenomenon the great and preponderating mass of flint *débris* from the Chalk hills, and of *sandstone* and *chert* from the Greensand hills of Surrey, leaves no reasonable doubt that the main bulk of the gravel of Clapham and of London has been derived and transported from the *Surrey downs* and *Sussex hills*."

Mr. Shrubsole sees a difficulty in the existence of a Wealden dome, which he considers open to question. But how, without higher ground than any in the Thames Valley, could *débris* from the Lower Greensands have drifted over the ground to the northward of it?

These remarks are not intended to convey any disparagement of Professor Phillips' excellent work, which I have often had occasion to study with advantage.

JOSEPH PRESTWICH.

BOULDERS OF ELÆOLITE-SYENITE IN EAST YORKSHIRE.

SIR,—The absence of the well-known elæolite-syenite (laurdalite of Brögger) from the Norwegian boulders hitherto identified in Holderness has more than once been mentioned, and is cited by Sir Henry Howorth in your August Number as in some way supporting his theory that the boulders were brought artificially as ballast. Why laurdalite should be less suitable for ballast than laurvikite does not appear. The non-recognition of the former is, of course, easily explained by its resemblance to the latter, which occupies a much larger area in the Christiania basin, and is correspondingly more plentiful among the boulders. Nevertheless it is satisfactory to be able to record the occurrence of the Norwegian elæolite-syenite on the Holderness coast. Visiting Dimlington a few months ago, I selected from the profusion of syenitic boulders on the beach eight which seemed worthy of closer study. These and the slices cut from them are now before me. Two contain abundant elæolite, and are identical in every respect with specimens of laurdalite from its original home; one or two others have accessory elæolite and sodalite.

Since these boulders were collected on the beach, the facts mentioned do not appeal to those who find comfort in the ballast theory. Indeed, it is not easy to see how Sir Henry Howorth can

be met at all. Passing over his travesty of my argument, which I suppose is not to be taken seriously, I find nothing in his article that does not evade the point. He first suggested that the records of Norwegian boulders on our East coast were due to observers having been deceived by material artificially transported. Thereupon I pointed out the well-known fact that such boulders are found imbedded in the Holderness clays, as well as on the beach. Of this he takes no explicit notice, but proceeds to shift his ground and throw doubt on the identification of the rocks in question. If Sir Henry will submit some of the disputed boulders to his eminent but anonymous petrological friend, the testimony of the latter will no doubt receive due weight; meanwhile, though a hundred witnesses may depose that they have *not* seen Scandinavian boulders in Yorkshire, the jury will listen rather to the evidence of one or two who *have* seen and investigated the matter.

St. John's College, Cambridge.
August 18th, 1894. Alfred Harker.

GLACIAL GEOLOGY.

Sir,—In your issue for August last Sir Henry H. Howorth, replying to a short letter in which I criticized an article of his you had printed, remarks: "I hope Mr. Harker and Mr. Deeley will continue to face the issues between us, and not be content, as others have been, with fulminating more or less testy protests, and then retiring from the field." It is clear that your correspondent here refers to a discussion which took place in the pages of "Nature" between himself and Dr. Alfred Russell Wallace. In that discussion Sir Henry H. Howorth, to discredit his opponent's views, denied the correctness of a statement made by Dr. Wallace. In reply, Dr. Wallace showed that Sir Henry H. Howorth had, in his "Glacial Nightmare," taken the same view as Dr. Wallace; and as Sir Henry H. Howorth would not admit that he had played fast and loose with his facts, Dr. Wallace very properly refused to further discuss the matter with him. Is it proper to call this retiring from the field with more or less testy protests? In my letter I charged Sir Henry H. Howorth with having misrepresented the teaching of two letters, one written by Prof. Bonney and the other by Prof. Hughes. In his reply we have no word of explanation or apology for this, or even reference to it; but instead an attack, delivered quite beside the mark, intended to throw discredit upon me. He also sneers at "English official geologists" as a body, so I can, at any rate, congratulate myself upon being in excellent company.

In face of the discussions which have already taken place—discussions in which it has been pointed out that, as far as is known, ice in bulk is plastic (that it has no *yield-point* in the sense that steel or even clay has, and that, therefore, so long as there is an upper slope to the ice the ice must move)—it would be useless to try to make the matter clearer in a letter. However, I will quote again from Sir Henry H. Howorth by way of illustration. He requires

an "adequate *vis a tergo*," and says: "That such a *vis a tergo* can only, in the case of such ice-sheets, be obtained by postulating a considerable slope to the ice surface is equally plain and equally admitted." Will Sir Henry H. Howorth kindly express the necessary slope to produce motion in degrees, and give the *yield-point* of ice by which this slope is controlled?

I would have answered Sir Henry H. Howorth before, but have been for a short tour in Switzerland with Mr. G. Fletcher, F.G.S. Shortly we hope to be able to put together some notes we then made on the structure of glacier ice. During our stay I was able to examine many of the larger glaciers, and also to reach the summit of Mont Blanc and compare true *névé* with true glacier ice.

R. M. Deeley.

CHANGES IN OLD LAND-SURFACES AND COAST-LINES IN THE GLACIAL PERIOD.

Sir,—For some time past I have been attempting to represent, by coloured diagrams, the gradual changes of the level of the land above the sea, and the relative altitude of the Hills in the British Islands in Pleistocene times, and up to the present period. It was, in my opinion, a great and prolonged denudation which took place during the first Glacial epoch, and after the maximum of glaciation was reached, a period of land submergence was also effected, and then commenced a gradual emergence, in which a wearing away in depressed areas progressed by action of the sea, leaving high-level drifts on the surface of Chalk and other rock formations; but the channels which now divide the French and English coasts, and the Isle of Wight from the mainland of Hampshire, had not been cut, and did not prevent the migration of the terrestrial inhabitants, the temperature reverting to a condition similar to that now prevailing. The inter-Glacial period, which we now designate as Palæolithic and Prehistoric, ensued. It was a mild climate which then prevailed, and continued for about 15,000 years duration, when there existed a fauna composed of Elephants, Rhinoceroses, Hippopotami, Bison, Musk-Ox, Irish Deer, Elks, Red Deer, Beavers, Wild Boars, Bears, Cave Lions, Hyænas, and other Carnivora. These creatures ranged through vast forests of Oaks, Elms, Yews, Fir Trees, with peat-mosses separating Arctic plants beneath from a flora of warmer times above.

At this time a race of men appeared whose intelligence was sufficient to enable them to provide for their wants and to engrave figures of animals and make weapons of stone and bone. We find their relics in caves and under the shelter of rocks, which have resisted destruction during the subsequent submergence to which they were exposed, and which must have continued for a period of about 15,000 years.

An ice-sheet covered the land, whilst it was submerged, to the depth of many hundred feet, and of this we have records in Scandinavia, in Canada, and also on Snowdon.

A question here arises, whether the vast thickness and weight of such an incumbent mass of ice, was not the true cause of the submergence. A change in the centre of gravity of the globe's surface will explain this. The subsidence of the land may well be referred to, as it is by Professor Prestwich, as that of the cause of the Traditional Deluge. This Glacial epoch seems gradually to have ceased and then again commenced a gradual elevation of the surface of the land above the sea, its outline becoming changed and modified accordingly, as its submarine rock-formations would have been subject to it, until its condition eventually became such as we now see it, with marine channels separating the British Islands, the Isle of Wight, and others from the Continent of Europe.

75, Kensington Gardens Square, Lambart Brickenden.

MISCELLANEOUS.

Manual of the Geology of India.—In the Geological Magazine for August (*ante*, p. 375) attention was called to the omission of the names of Messrs. H. B. Medlicott and W. T. Blanford, the authors of the Manual of the Geology of India, from the title-page of the new edition. We are gratified to learn that, the circumstance having been brought to the notice of the Government of India, orders have been given by the Government for a new title-page, with the names inserted to be substituted for that first issued.

International Geological Congress, Zurich.—At the instance of Captain Marshall Hall, the Geological Congress at Zurich decided upon appointing an International Committee to report upon existing glaciers. As soon as the constitution of this committee is completed we hope to give details of the work it is to be charged with and its members.

The Geology of South Shropshire.—Fifty-nine pages of the August Number of the Proceedings of the Geologists' Association are devoted to an admirable description of "The Geology of South Shropshire," by Prof. C. Lapworth, LL.D., F.R.S., and W. W. Watts, M.A., F.G.S., illustrated by twenty-three woodcuts and two plates. On this historic ground so many eminent geologists have laboured and so much has been published, that it is no small boon to Associates to be able to obtain, in so small a space, so excellent an epitome of this interesting and important British area. The illustrations embrace a good Map and a large number of sections, a capital table of the Lower Palæozoic rocks of Shropshire, with the subdivisions proposed by various authors from 1830 to 1894, viz.: Sedgwick, Murchison, the Geological Survey, Barrande, Lyell, Geikie, Barrois, Bigot, de Lapparent, Lapworth, Callaway, Hicks, Nicholson, etc. The Geologists' Association are to be congratulated upon securing for their Proceedings so valuable a contribution, which is also descriptive of the area that has formed the object of their long excursion this summer, from July 29th to August 4th.